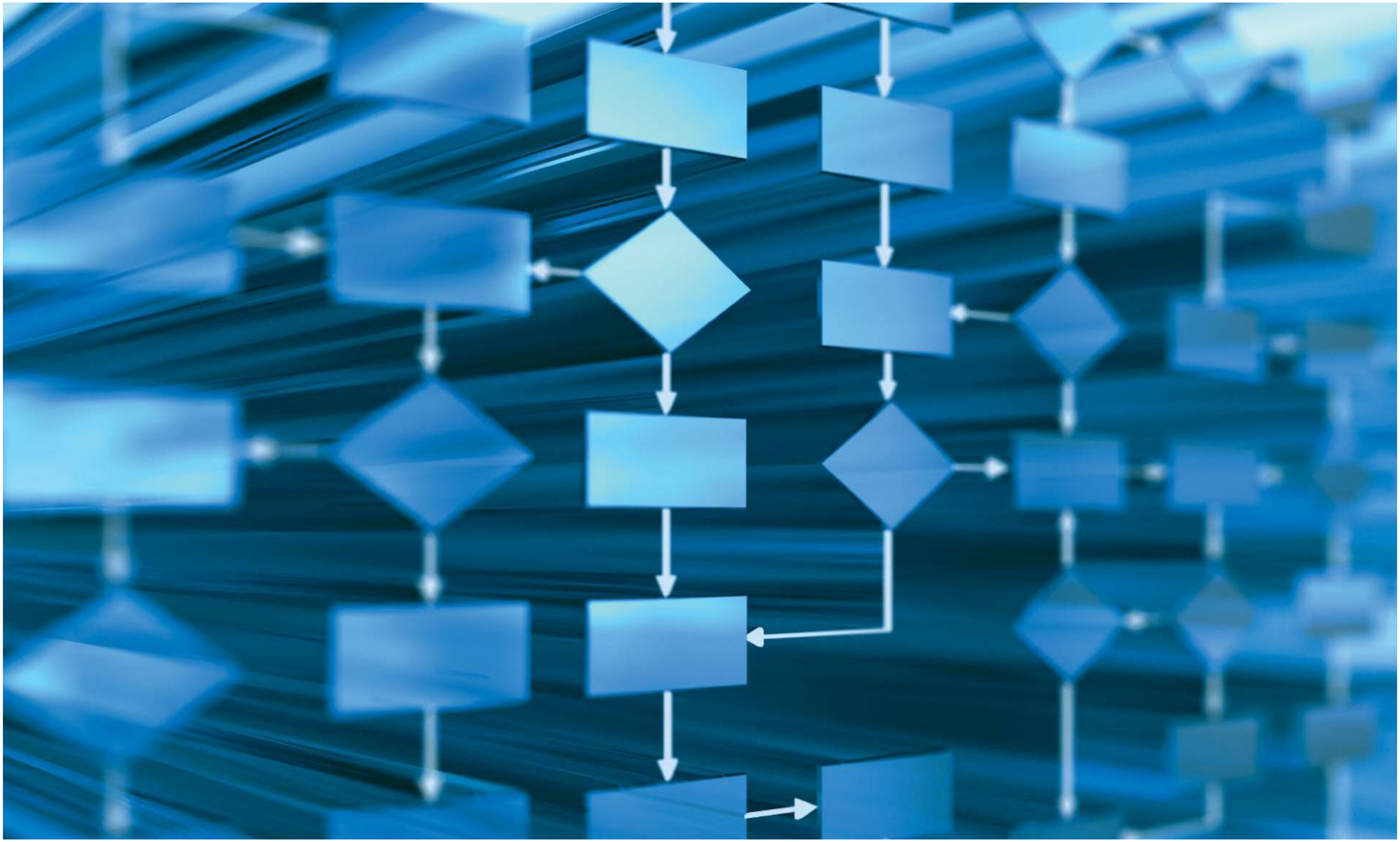

March 2013

National energy Efficiency
Technology Roadmap Portfolio

APPENDIX A:
Process documents

Enhanced PDF Functionality

Functionality of the PDF version of this document has been enhanced in the following ways:

- **Bookmarks:** Enabled PDF reader applications (i.e., Adobe Acrobat) can navigate this document using the Bookmark feature.
- **Embedded Links:** The Table of Contents has been linked to the appropriate sections of the document.
- **"Back to Table of Contents":** In the footer of even-numbered pages is an embedded hyperlink back to the Table of Contents.
- **Control + F:** As always, one can navigate through the document by searching for specific words or phrases by pressing the "Control" and "F" keys simultaneously.

Table of Contents

Introduction

This appendix contains process documents and related files that pertain to the ongoing expansion and refinement of the *National Energy Efficiency Technology Roadmap Portfolio* (*Roadmap Portfolio*). The project team has developed this companion document in the interest of providing full visibility into the various roadmapping workshop agendas, participants, contributors, and transcripts.

For an overview of the purpose and history of energy efficiency technology roadmapping within the Pacific Northwest, and to make use of individual roadmaps, the reader is invited to review the most recent version of the *Roadmap Portfolio* available at the Bonneville Power Administration's Energy Efficiency Emerging Technology website (http://www.bpa.gov/energy/n/emerging_technology/). This website also features a link to Appendix B of the *Roadmap Portfolio* that provides more details on existing research, development, and deployment programs identified in the portfolio.

You are invited to direct any and all questions and comments to project manager James V. Hillegas-Elting (jvhillegas@bpa.gov, 503.230.5327).

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Appendix A1:
Roadmapping Workshop Participation

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National Energy Efficiency Technology Roadmap Portfolio: Workshop Participation

— December 2009 through September 2012 —

Workshop 1 (Drivers, Products/Services, Performance Goals) (Dec. 3-4, 2009)

1.	Jack Callahan	Bonneville Power Administration
2.	Todd Currier	Washington State University Energy Program
3.	Phile Degens	Energy Trust of Oregon
4.	Ryan Fedie	Bonneville Power Administration
5.	Charlie Grist	NW Power & Conservation Council
6.	Jeff Harris	NW Energy Efficiency Alliance
7.	Rem Husted	Puget Sound Energy
8.	Dave Holmes	Avista
9.	Mark Leddbetter	Pacific Northwest National Lab
10.	Terry Oliver	Bonneville Power Administration
11.	Pete Pengilly	Idaho Power
12.	Tom Reddoch	Electric Power Research Institute
13.	Mark Rehley	NW Energy Efficiency Alliance
14.	Mary Smith	Snohomish PUD

Subgroups

- **Building Design/Envelope for Retrofit & New Construction:** Husted, Pengilly, Degens
- **Hot Water and HVAC:** Harris, Smith, Fedie
- **Electronics and Lighting:** Ledbetter, Reddoch, Rehley
- **Sensors, Meters, and Energy Management Systems:** Callahan, Currier, Holmes, *Oliver*

Workshop 2 (Technologies and Gaps) (Jan. 20, 2010)

1.	Mark Brune	PAE Consulting Engineers
2.	Jack Callahan	Bonneville Power Administration
3.	Dan Colbert	U.C. Santa Barbara, Institute for Energy Efficiency
4.	Todd Currier	Washington State University Energy Program
5.	Ryan Fedie	Bonneville Power Administration
6.	Fred Gordon	Energy Trust of Oregon
7.	Jeff Harris	NW Energy Efficiency Alliance
8.	Reid Hart	Portland Energy Conservation, Inc.
9.	Rem Husted	Puget Sound Energy
10.	Bill Koran	Quest
11.	Bill Livingood	National Renewable Energy Laboratory
12.	Jonathan Livingston	Livingston Energy Innovations
13.	Terry Oliver	Bonneville Power Administration
14.	Nick O'Neil	Energy Trust of Oregon
15.	Graham Parker	Pacific Northwest National Lab
16.	Pete Pengilly	Idaho Power
17.	Rob Penney	Washington State University Energy Program
18.	Tom Reddoch	Electric Power Research Institute
19.	Mark Rehley	NW Energy Efficiency Alliance
20.	Dave Roberts	National Renewable Energy Laboratory
21.	Mary Smith	Snohomish PUD
22.	Jack Zeiger	Washington State University Energy Program

Subgroups

- **Heating, Ventilation, and Air Conditioning:** Zeiger, Rehley, Brune, Hart, O'Neil, Currier
- **Building Design/Envelope** New Construction & Retrofits: Fedie, Parker, Husted, Roberts
- **Electronics and Lighting:** Reddoch, Penney, Pengilly, Gordon, Colbert, Livingston
- **Sensors, Meters, and Energy Management Systems:** Smith, Oliver, Callahan, Livingood, Koran

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Workshop 3 (Market Interventions, Programs, and Other Initiatives) (Jan. 21, 2010)

1.	Mike Bailey	Ecos
2.	Mark Brune	PAE Consulting Engineers
3.	Todd Currier	WSU Extension Energy Program
4.	Fred Gordon	Energy Trust of Oregon
5.	Jeff Harris	NW Energy Efficiency Alliance
6.	Ray Hartwell	Bonneville Power Administration
7.	Rem Husted	Puget Sound Energy
8.	Mike Hoffman	Pacific NW National Laboratory
9.	Gary Keyes	PCS UtilliData
10.	Carol Lindstrom	Bonneville Power Administration
11.	Jonathan Livingston	Livingston Energy Innovations
12.	Laurence Orsini	Portland Energy Conservation, Inc.
13.	Pete Pengilly	Idaho Power
14.	Rob Penney	Washington State University Energy Program
15.	Tom Reddoch	Electric Power Research Institute
16.	Mark Rehley	NW Energy Efficiency Alliance
17.	James Thomas	Glumac
18.	Kim Thompson	Bonneville Power Administration
19.	Jeremy Wilson	PCS UtiliData
20.	Jack Zeiger	Washington State University Energy Program

Subgroups

- **Building Design, Performance, Envelope:** Lindstrom, Zeiger, Brune, Pengilly, Currier
- **Water Heating and HVAC:** Thomas, Gordon, Hartwell, Husted
- **Lighting, Electronics, Appliances:** Penney, Reddoch, Orsini
- **Machine Drives, Waste Energy Recovery and CHP; Other (Industrial, Commercial, Agricultural, Institutional):** Bailey, Keyes, Wilson, Rehley
- **EMS; Sensors and Meters:** Harris, Hoffman, Livingston

Workshop 4 (Prioritization) (Feb. 5, 2010)

1.	Jack Callahan	Bonneville Power Administration
2.	Todd Currier	Washington State University Energy Program
3.	Ryan Fedie	Bonneville Power Administration
4.	Fred Gordon	Energy Trust of Oregon
5.	Charlie Grist	NW Power & Conservation Council
6.	Jeff Harris	NW Energy Efficiency Alliance
7.	Rem Husted	Puget Sound Energy
8.	Mike Hoffman	Pacific NW National Laboratory
9.	Terry Oliver	Bonneville Power Administration
10.	Graham Parker	Pacific NW National Laboratory
11.	Tom Reddoch	Electric Power Research Institute
12.	Mark Rehley	NW Energy Efficiency Alliance
13.	Mary Smith	Snohomish PUD

Food Processing Industry Workshop (Aug. 18, 2011)

1. Pam Barrow — Northwest Food Processors Association
2. Corey Corbett — Puget Sound Energy
3. Mike Eagen — Trident Seafoods
4. Jennifer Eskil — Bonneville Power Administration
5. Mike Henderson — ConAgra Foods
6. Rem Husted — Puget Sound Energy
7. Mike Hoffman — Pacific NW National Laboratory
8. Dave Holmes — Avista
9. Gray Johnson — Oregon Freeze Dry, Inc.
10. Pete Lepschat — Henningsen Cold Storage Co.
11. Qingyue Ling — Oregon State University
12. John Marshall — Northwest Food Processors Association
13. Graham Parker — Pacific NW National Lab.
14. Mike Penner — Oregon State University
15. Rob Penney — Washington State University Energy Program
16. Jim Peterson — Cold Solutions, LLC
17. Mark Rehley — Northwest Energy Efficiency Alliance
18. Steven Scott — MetaResource Group
19. Mark Steele — NORPAC Foods, Inc.
20. Don Sturtevant — J.R. Simplot, Co.
21. Juming Tang — Washington State University
22. Judy Thoet — Washington Association of Wine Grape Growers
23. Randy Thorn — Idaho Power
24. John Thornton — Northwest Food Processors Association
25. Geoff Wickes — Northwest Energy Efficiency Alliance
26. Marcus Wilcox — Cascade Energy, Inc.
27. Bill Wilson — Washington State University Energy Program

Subgroups

- **Cooling:** Henderson, Lepschat, Penny, Peterson, Steele, Thorn, Thoet, Wilcox, Wilson
- **Heating:** Henderson, Ling, Steele, Tang, Thorn, Thornton, Thoet, Wilson
- **Mechanical:** Eskil, Ling, Parker, Rehly, Sturtevant
- **Infrastructure:** Barrow, Ling, Scott, Penner, Penney, Wickes

Combined Heat and Power Workshop (Dec. 15, 2011)

1. Todd Amundson — Bonneville Power Administration
2. Chuck Collins — Cascade Power Group
3. Whitney Colella — Pacific Northwest National Laboratory
4. Ken Corum — NW Power and Conservation Council
5. Jennifer Eskil — Bonneville Power Administration
6. Mark Fuchs — Washington State Dept. of Ecology
7. Mike Henderson — ConAgra Foods
8. Steve Knudsen — Bonneville Power Administration
9. Mark Lynn — Simplot
10. Chris McCalib — Lakehaven (WA) Utility District
11. Chris Milan — Bonneville Power Administration
12. Graham Parker — Pacific NW National Lab.
13. Tom Reddoch — Electric Power Research Institute
14. Carolyn Roos — Washington State University
15. Eric Simpkins — fuel cell industry
16. Dave Sjoding — Washington State University
17. John Thornton — Northwest Food Processors Association
18. Juliana Williams — Cascade Power Group
19. Bill Wilson — Washington State University Energy Program

Subgroups

- **Production & Resources:** Colella, Fuchs, Knudsen, McCalib, Reddoch, Roos, Sjoding, Thornton, Wilson
- **Delivery & Resources:** Amundson, Collins, Corum, Eskil, Henderson, Lynn, Milan, Parker, Simpkins, Williams

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Drivers & Capability Gaps Workshop (Aug. 8, 2012)

Building Design / Envelope

1.	Amanda Ayoub	Portland Energy Conservation, Inc.
2.	Michael Baechler	Pacific Northwest National Lab
3.	Lauren Casentini	Resource Solutions Group
4.	Todd Currier	Washington State University Energy Program
5.	Jeff Gleeson	Pacific Gas & Electric
6.	Rem Husted	Puget Sound Energy
7.	Mark Johnson	Bonneville Power Administration
8.	Michael Little	Seattle City Light
9.	Bruce Manclark	Fluid Marketing Strategies
10.	Pete Pengilly	Idaho Power
11.	Dave Roberts	National Renewable Energy Laboratory
12.	Jack Zeiger	Washington State University Energy Program
13.	Brian Zoeller	Bonneville Power Administration

Electronics

14.	Gregg Hardy	Ecova
15.	Jeff Harris	NW Energy Efficiency Alliance
16.	Jonathan Livingston	Livingston Energy Innovations
17.	Aaron Panzer	Pacific Gas & Electric Co.
18.	Thomas Reddoch	Electric Power Research Institute

Heating, Ventilation, & Air Conditioning

19.	Dave Baylon	Ecotope
20.	Ryan Fedie	Bonneville Power Administration
21.	Ellen Petrill	Electric Power Research Institute
22.	Mary Smith	Snohomish County PUD
23.	Charlie Stephens	NW Energy Efficiency Alliance
24.	Jim Volkman	Strategic Energy Group

Lighting

25.	Dave Hewitt	New Buildings Institute
26.	Nock, Levin	Bonneville Power Administration
27.	Rob Penney	Washington State University Energy Program
28.	Mark Rehley	NW Energy Efficiency Alliance
29.	Paul Sklar	Energy Trust of Oregon
30.	Jennifer Williamson	Bonneville Power Administration
31.	Gregg Kelleher	Eugene Water and Electric Board

Sensors, Meters, & Energy Management Systems

32.	Gregg Ander	Southern California Edison
33.	Joe Barra	Portland General Electric
34.	Callahan, Jack	Bonneville Power Administration
35.	Joan Effinger	Portland Energy Conservation, Inc.
36.	Erin Erben	Eugene Water and Electric Board
37.	Cathy Higgins	New Buildings Institute
38.	Jorge Marques	BC Hydro
39.	Paul Mathew	Lawrence Berkeley National Laboratory
40.	William Livingood	National Renewable Energy Laboratory

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
3.	James V. Hillegas	Bonneville Power Administration
4.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
5.	Joseph Thomas	Bonneville Power Administration

Sensors, Meters, and Energy Management Systems Workshop (Sep. 24, 2012)

Group A: Energy Management Services

1.	Chad Corbin	Tendril
2.	Erin Erben	Eugene Water & Electric Board
3.	Marshall Hunt	Pacific Gas & Electric Co.
4.	Eric Martinez	San Diego Gas & Electric
5.	Allie Robbins Mace	Bonneville Power Administration

Group B: Enterprise Energy and Maintenance Management Systems

6.	Mike Bailey	Ecova
7.	Paul Ehrlich	Building Intelligence Group
8.	Mark Firestone	PAE Consulting Engineers
9.	Hanna Kramer	Portland Energy Conservation, Inc.
10.	Bill Livingood	National Renewable Energy Laboratory
11.	Carl Neilson	Delta Controls
12.	Alecia Ward	Weidt Group

Group C: Real-Time Smart Electric Power Measurement of Facilities

13.	Bruce Baccei	Sacramento Municipal Utility District
14.	Hampden Kuhns	LoadIQ LLC
15.	Irfan Rehmanji	BC Hydro
16.	Nate Taylor	San Diego Gas & Electric

Group D: Low-Cost Savings Verification Techniques

17.	Jack Callahan	Bonneville Power Administration
18.	Terry Egnor	MicroGrid Inc.
19.	Suzanne Frew	Snohomish County PUD
20.	Bryan Hulsizer	Optimal Energy
21.	Paul Mathew	Lawrence Berkeley National Laboratory
22.	Harvey Sachs	American Council for an Energy-Efficient Economy
23.	Brinda Thomas	Carnegie Mellon University
24.	Phoebe Carner Warren	Seattle City Light

Group E: Smart Device-Level Controls Responsive to User and Environment; Easy/Simple User Interface Controls

25.	Abdullah Ahmed	Sempra Utilities
26.	Brad Acker	University of Idaho Integrated Design Laboratory
27.	Doug Avery	Southern California Edison
28.	Lieko Earle	National Renewable Energy Laboratory
29.	Jeff Harris	NW Energy Efficiency Alliance
30.	Dick Lord	Carrier Corp.
31.	Jim McMahon	Better Climate
32.	Igor Mezić	University of Calif. Santa Barbara
33.	Ram Narayanmurthy	Electric Power Research Institute
34.	Jay Stein	E Source

Other Participants

35.	Lew Harriman	Mason-Grant Consulting
36.	David Kenney	Oregon Built Environment & Sustainable Technologies Ctr.
37.	Pete Pengilly	Idaho Power Company

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Debra Bristow	Bonneville Power Administration
3.	Kelly Cowan	Portland State Univ. Engineering and Tech. Mgmt. Dept.
4.	Ben Clarin	Electric Power Research Institute
5.	Edwin Garces	Portland State Univ. Engineering and Tech. Mgmt. Dept.
6.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
7.	James V. Hillegas	Bonneville Power Administration
8.	Sara Inwood	Electric Power Research Institute
9.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
10.	Jonathan Livingston	Livingston Energy Innovations
11.	Rob Penney	Washington State University Energy Program
12.	Ellen Petrill	Electric Power Research Institute
13.	Joel Scruggs	Bonneville Power Administration
14.	Yulianto Suharto	Portland State Univ. Engineering and Tech. Mgmt. Dept.
15.	Kevin van Blommestein	Portland State Univ. Engineering and Tech. Mgmt. Dept.
16.	Jack Zeiger	Washington State University Energy Program

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Lighting Workshop (Sep. 25, 2012)

Group A: General Lighting

1.	Craig Ciranny	Bonneville Power Administration
2.	Charlie Grist	NW Pwr and Conservation Council
3.	Gregg Hollingsworth	Topanga
4.	Laura Moorefield	Ecova
5.	Kurt Nielson	Light Doctor
6.	Brian Patterson	Armstrong World Industries / EMerge Alliance
7.	Gerald Rea	Stray Light Optical
8.	Jeremy Snyder	Rensselaer Polytechnic Institute Lighting Research Center

Group B: Solid State Lighting

9.	Marc Ledbetter	Pacific Northwest National Lab
10.	Jon Linn	Northeast Energy Efficiency Partnerships
11.	Levin Nock	Bonneville Power Administration
12.	Graham Parker	Pacific Northwest National Lab
13.	Martin Shelley	Idaho Power Company
14.	Joe Vaccher	Eugene Water & Electric Board
15.	Carolyn Weiner	Pacific Gas & Electric
16.	Jerry Wright	Seattle City Light

Group C: Lighting Controls + Daylighting

17.	Doug Avery	Southern California Edison
18.	Brian Fortenbery	Electric Power Research Institute
19.	Grant Grable	SunOptics
20.	Robert Guglielmetti	National Renewable Energy Lab
21.	Michael Lane	Puget Sound Energy
22.	Kosta Papamichael	University of California Davis
23.	Joeseph A. Paradiso	Massachusetts Institute of Technology
24.	Michael Poplawski	Pacific Northwest National Lab
25.	Mark Rehley	NW Energy Efficiency Alliance
26.	Irfan Rehmanji	BC Hydro
27.	Paul Savage	Nextek Power Systems
28.	Dave Thompson	Avista Corporation
29.	Cory Vanderpool	EnOcean Alliance

Group D: Task/Ambient Lighting; Luminaires

30.	Terry Clark	Finelite
31.	Karl Johnson	California Institute for Energy and Environment at UC Davis
32.	Tom Reddoch	Electric Power Research Institute
33.	Michael Siminovitch	University of California Davis
34.	Eric Strandberg	Lighting Design Lab
35.	Mark Whitney	Portland General Electric

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Debra Bristow	Bonneville Power Administration
3.	Kelly Cowan	Portland State Univ. Engineering and Tech. Mgmt. Dept.
4.	Ben Clarin	Electric Power Research Institute
5.	Edwin Garces	Portland State Univ. Engineering and Tech. Mgmt. Dept.
6.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
7.	James V. Hillegas	Bonneville Power Administration
8.	Sara Inwood	Electric Power Research Institute
9.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
10.	Jonathan Livingston	Livingston Energy Innovations
11.	Rob Penney	Washington State University Energy Program
12.	Ellen Petrill	Electric Power Research Institute
13.	Joel Scruggs	Bonneville Power Administration
14.	Yulianto Suharto	Portland State Univ. Engineering and Tech. Mgmt. Dept.
15.	Kevin van Blommestein	Portland State Univ. Engineering and Tech. Mgmt. Dept.
16.	Jack Zeiger	Washington State University Energy Program

Building Design & Envelope Workshop (Sep. 26, 2012)

Group A (Retrofit and New Construction Windows; Insulated Shades; Daylighting)

1.	Charlie Ćurčija	Lawrence Berkeley National Lab
2.	Jim Larsen	Cardinal Glass Industries
3.	Kosta Papamichael	Univ. of Calif. Davis Calif. Lighting Technology Ctr.

Group B (Retrofit Insulation; New Construction Insulation; Transformative Building Materials; Eliminating Home Penetrations; Air Sealing)

4.	Todd Currier	Washington State University Energy Program
5.	André Desjarlais	Oak Ridge National Lab
6.	Peter Douglas	New York State Energy Research and Development Authority
7.	Mark Modera	University of California Davis Western Cooling Efficiency Ctr.
8.	Sriram Somasundaram	Pacific Northwest National Lab
9.	Theresa Weston	Dupont Innovations
10.	Sarah Widder	Pacific Northwest National Lab

Group C (Zero Net Energy; Manufactured Housing; Solar/Smart Roofing)

11.	Ammi Amarnath	Electric Power Research Institute
12.	Ren Anderson	National Renewable Energy Lab
13.	G.Z. (Charlie) Brown	University of Oregon
14.	Jack Callahan	Bonneville Power Administration
15.	Rob Hammon	Consol, Inc.
16.	Tom Hootman	RNL Design
17.	Karl Johnson	California Institute for Energy and Environment (CIEE) at UC Davis
18.	Michael Lubliner	Washington State University Energy Program
19.	Paul Torcellini	National Renewable Energy Lab

Group D (Deep Retrofits)

20.	Amanda Ayoub	Portland Energy Conservation, Inc.
21.	Johanna Brickman	Oregon Built Environment & Sustainable Technologies Ctr.
22.	John Jennings	NW Energy Efficiency Alliance
23.	Lew Harriman III	Mason-Grant Consulting
24.	Rem Husted	Puget Sound Energy
25.	Michael Little	Seattle City Light
26.	Gordon Monk	BC Hydro
27.	Pete Pengilly	Idaho Power Company
28.	Dave Roberts	National Renewable Energy Lab
29.	Eric Strandberg	Lighting Design Lab
30.	Omar Siddiqui	Electric Power Research Institute
31.	Alecia Ward	Weidt Group
32.	Eric Werling	U.S. Department of Energy Building America Program

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Debra Bristow	Bonneville Power Administration
3.	Kelly Cowan	Portland State Univ. Engineering and Tech. Mgmt. Dept.
4.	Ben Clarin	Electric Power Research Institute
5.	Edwin Garces	Portland State Univ. Engineering and Tech. Mgmt. Dept.
6.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
7.	James V. Hillegas	Bonneville Power Administration
8.	Sara Inwood	Electric Power Research Institute
9.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
10.	Jonathan Livingston	Livingston Energy Innovations
11.	Rob Penney	Washington State University Energy Program
12.	Ellen Petrill	Electric Power Research Institute
13.	Joel Scruggs	Bonneville Power Administration
14.	Yulianto Suharto	Portland State Univ. Engineering and Tech. Mgmt. Dept.
15.	Kevin van Blommestein	Portland State Univ. Engineering and Tech. Mgmt. Dept.
16.	Jack Zeiger	Washington State University Energy Program

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Heating, Ventilation, and Air Conditioning Workshop (Sep. 27, 2012)

Group A (Motor-driven Systems; Heating & Cooling Production and Delivery)

1.	Bruce Baccei	Sacramento Municipal Utility Distr.
2.	Chris Bellshaw	Daikin (Americas) Inc.
3.	Ryan Fedie	Bonneville Power Administration
4.	Mark Firestone	PAE Consulting Engineers
5.	Jared Sheeks	MacDonald-Miller Facility Solutions, Inc
6.	Greg Towsley	Grundfos
7.	Xudong Wang	Air-Conditioning Heating, and Refrigeration Institute

Group B (Heat Recovery & Economizer Optimization; Fault Detection and Predictive Maintenance)

8.	Mark Cherniak	New Buildings Institute
9.	Jerine Ahmed	Southern California Edison
10.	Reid Hart	Pacific Northwest National Lab
11.	Kristin Heinemeier	University of California Davis, Western Cooling Efficiency Ctr.
12.	Srinivas Katipamula	Pacific Northwest National Lab
13.	Phoebe Carner Warren	Seattle City Light

Group C (Water Heating)

14.	Amanda Ayoub	Portland Energy Conservation, Inc.
15.	Mike Lubliner	Washington State University Energy Program
16.	Graham Parker	Pacific Northwest National Lab
17.	Mark Rehley	NW Energy Efficiency Alliance
18.	Stephanie Vasquez	Bonneville Power Administration

Group D (Residential HVAC Systems)

19.	Dave Baylon	Ecotope Inc.
20.	Kyle Gluesenkamp	University of Maryland
21.	Todd Greenwell	Idaho Power Company
22.	Marshall Hunt	Pacific Gas & Electric Co.
23.	Mark Johnson	Bonneville Power Administration
24.	John Karasaki	Portland General Electric
25.	Bruce Verhei	MountainLogic, Inc.

Group E (Commercial Integrated Systems)

26.	Philip Haves	Lawrence Berkeley National Lab
27.	John Heller	Ecotope Inc.
28.	Richard Lord	Carrier Corp.
29.	Harvey Sachs	American Council for an Energy-Efficient Economy
30.	Pradeep Vitta	Southern Company
31.	Chris Wolgamott	Eugene Water & Electric Board
32.	Robert Wilkins	Danfoss

Group F (Modeling, Lab, and Field Testing)

33.	Ahmed Abdullah	San Diego Gas & Electric / Sempra Utilities
34.	Marc Brune	PAE Consulting Engineers
35.	Jack Callahan	Bonneville Power Administration
36.	Ron Domitrovic	Electric Power Research Institute
37.	Suzanne Frew	Snohomish County PUD
38.	Nicholas Long	National Renewable Energy Lab

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Debra Bristow	Bonneville Power Administration
3.	Kelly Cowan	Portland State Univ. Engineering and Tech. Mgmt. Dept.
4.	Edwin Garces	Portland State Univ. Engineering and Tech. Mgmt. Dept.
5.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
6.	James V. Hillegas	Bonneville Power Administration
7.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
8.	Jonathan Livingston	Livingston Energy Innovations
9.	Ellen Petrill	Electric Power Research Institute
10.	Yulianto Suharto	Portland State Univ. Engineering and Tech. Mgmt. Dept.
11.	Kevin van Blommestein	Portland State Univ. Engineering and Tech. Mgmt. Dept.

Electronics Workshop (Sep. 27, 2012)

Group A (Component-level Efficiency; Complete Electronic Systems)

1.	Brian Fortenbery	Electric Power Research Institute
2.	Yung-Hsiang Lu	Purdue University
3.	David Thompson	Avista Corporation
4.	My Ton	Collaborative Labeling and Appliance Standards Program

Group B (Use and Virtualization)

5.	Ren Anderson	National Renewable Energy Lab
6.	Massoud Jourbachi	NW Power and Conservation Council
7.	Mukesh Khattar	Oracle Corporation
8.	Tony Lai	Delta Electronics
9.	Mark Monroe	Energetic Consulting
10.	Tom Reddoch	Electric Power Research Institute
11.	Dennis Symanski	Electric Power Research Institute

Group C (Interlock Devices to Manage Energy Use; Sleep Mode)

12.	Lieko Earle	National Renewable Energy Lab
13.	Gary Hamer	BC Hydro
14.	Gregg Hardy	Ecova
15.	A.J. Howard	Energy Market Innovations
16.	Emily Kemper	Portland Energy Conservation, Inc.
17.	Bruce Nordman	Lawrence Berkeley National Lab
18.	Danny Parker	University of Central Florida, Florida Solar Energy Ctr.

Group D (Direct Current Power Source)

19.	David Geary	StarLine DC Solutions (A Division of Universal Electric Corp.)
20.	Jim McMahon	Better Climate
21.	B.J. Sonnenberg	Emerson Network Power Energy Systems, USA
22.	Dennis Symanski	Electric Power Research Institute
23.	Paul Torcellini	National Renewable Energy Lab

Other Participants

24.	Tyler Dillavou	Bonneville Power Administration

Facilitators & Support Staff

1.	Joshua D. Binus	Bonneville Power Administration
2.	Debra Bristow	Bonneville Power Administration
3.	Kelly Cowan	Portland State Univ. Engineering and Tech. Mgmt. Dept.
4.	Edwin Garces	Portland State Univ. Engineering and Tech. Mgmt. Dept.
5.	Tugrul Daim	Portland State Univ. Engineering and Tech. Mgmt. Dept.
6.	Ibrahim Iskin	Portland State Univ. Engineering and Tech. Mgmt. Dept.
7.	Jonathan Livingston	Livingston Energy Innovations
8.	Rob Penney	Washington State University Energy Program
9.	Yulianto Suharto	Portland State Univ. Engineering and Tech. Mgmt. Dept.
10.	Kevin van Blommestein	Portland State Univ. Engineering and Tech. Mgmt. Dept.
11.	Jack Zeiger	Washington State University Energy Program

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Appendix A2:

Workshop 1 (Drivers, Products and Services, and Goals) (Dec. 3-4, 2009)

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Northwest Energy Efficiency Technology Roadmap Workshop

WORKSHOP 1: Drivers, Products, Services, and Gaps

Agenda

Purpose of Workshop Series:

- To develop the framework for identifying, selecting, and prioritizing high-value, emerging energy efficiency (EE) research, development, and commercialization to be pursued by Northwest organizations and agencies

Purpose of Workshop #1:

- Identify, discuss, and prioritize energy efficiency drivers in the Northwest by end-use sector
- Identify, discuss, and prioritize energy efficiency product and services gaps in the Northwest
- Identify, discuss, and present performance goals for new products and services that will address the drivers and gaps previously identified

Thursday December 3, 2009

10:00 am **Welcome and Overview**

- **Joshua Binus**, *Bonneville Power Administration*
- **Terry Oliver**, *Bonneville Power Administration*
- **Tugrul Daim**, *Portland State University*

10:15 am **Current Energy Efficiency Research, Development, and Commercialization in the Northwest**

- Participant Introductions and Presentations on Current Energy Efficiency Research, Development, and Commercialization in the Northwest

11:00 am **Facilitation Ground Rules**

- **Jan Brinch**, *Energetics Incorporated*

11:10 am **Energy Efficiency Drivers in the Northwest**

FOCUS QUESTION #1: Given the status of energy efficiency in the Northwest, and what has driven our activities to date, what drivers are expected to impact EE products and services in the next 5-10-20 years within each end-use sector (residential, commercial, industrial, and agriculture)?

Noon **Working Lunch – Continue Drivers Discussion**

1:30 pm **EE Product and Service Gaps – What Is Missing?**

- Review of Energy Efficiency Products and Services That Already Exist in the Northwest
  - All Participants

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2:00 pm **Product and Service Gaps**

FOCUS QUESTION #2: Given the drivers, what EE products and services are not in the marketplace or are in the marketplace but not widely adopted?

3:45 pm **Break**

4:15 pm **Review Results of Product and Service Gaps**

- All Participants

4:45 pm **Review of First Day Outcomes – Drivers and Product and Service Gaps**

5:00 pm **Adjourn Day 1**

Friday, December 4, 2009

8:30 am **Recap of Day 1**

- EE Product and Service Drivers and Gaps
- Objectives of Day 2 – What EE products and services need attention?
  - **Joshua Binus**, *Bonneville Power Administration*
  - **Tugrul Daim**, *Portland State University*

9:00 am **Performance Attributes of EE Performance Goals**

- **Jeff Harris**, *Northwest Energy Efficiency Alliance*

9:20 am **Performance Goals for High Priority Product and Service Gaps/ Needs**

- Small Group Discussions by End-Use Sectors

FOCUS QUESTION #3: For the top priority product and service gaps identified yesterday, what are the performance goals that need to be established?

11:30 am **Small Group Reports**

- Reports from Each Small Group

12:30 pm **Working Lunch – Cross-Cutting Themes**

- Discussion of Goals and Dates for Next Three Workshops
  - **Jan Brinch**, *Energetics Incorporated*
  - **Joshua Binus**, *Bonneville Power Administration*

1:00 pm **Closing Comments and Adjourn**

1:15 pm **Regional Emerging Technology Advisory Committee Meeting**

3:00 pm **BPA EE Workshop Planning Team Meeting**

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY

ROADMAPPING WORKSHOP # 1:

DRIVERS, PRODUCTS, SERVICES, AND GAPS

MEETING MINUTES

DECEMBER 3-4, 2009

Participants

Jack Callahan, BPA	Charlie Grist, NWPCC	Mark Ledbetter, PNNL	Tom Reddoch, EPRI
Todd Currier, WSU Energy Extension Service	Jeff Harris, NEEA	Terry Oliver, BPA	Mark Rehley, NEEA
Phil Degens, Energy Trust	Dave Holmes, Avista	Pete Pengilly, Idaho Power	Mary Smith, Snohomish PUD
Ryan Fedie, BPA	Rem Husted, PSE		

Project Administration:

Project Manager: Joshua Binus, BPA
Consultant: Tugrul Daim, Portland State University
Support: Ji Sun Kim, Portland State University

Workshop Facilitation: Jan Brinch, Energetics
Ndeye Fall, Energetics
Brian Marchionini, Energetics

Welcome & Roadmapping Overview

BRINCH: Thank you for taking the time to come to the first workshop for the Northwest Energy Efficiency Technology Roadmapping. Workshops 2-4 are nailed down for dates. We explored many strategies and have set an agenda that we think works best. The goal is to have valuable products at the end of the workshop.

OLIVER: I would like to welcome everyone to the Pacific Northwest. When BPA restarted our R&D program, we were trying to figure out how to build the best research portfolio. We didn't want to do the same old research. We wanted to have roadmaps for Transmission, physical security, and Energy Efficiency (EE). Our first EE roadmap is outdated. We are heading this way to update this roadmap with emerging technologies in EE. We wanted to get a broader engagement across the region. We will use the roadmap as we see fit and deal with near and long-term opportunities.

DAIM: Welcome to workshop number 1. At end of the workshop series, we'll fill out a roadmap similar to the one in your red packet. Today and tomorrow, we'll confirm drivers and developing gaps of products and services. The second workshop will focus on in-depth research. The third workshop will focus on market barriers.

Workshop Participant Introductions:

BRINCH: We want to have everyone introduce themselves. Talk about the EE technologies and R&D work you are doing.

REHLEY: I work with Jeff in the Emerging Technologies (ET) group at NEEA. If you look at the list of technologies and products in the power plan, it is long and growing. I am interested in the work and finding out which products and technologies in the Power Plan to put the structure together.

OLIVER: I am the CTO at BPA. I manage the R&D portfolio at BPA, except for in the area of fish and wildlife. Our portfolio includes renewable energy, transmission, and the smart grid, among other things.

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HARRIS: I am the other half of ET at NEEA. We are restarting work on emerging technologies. In the past it was an ad-hoc process. We are now developing a screening and selection process. We want to do this in a structured way.

CURRIER: We focus on technologies that need near market R&D. We are working with Jack on fact checking. We research information on emerging technologies. The capabilities of the WSU program are unique in breadth and depth.

CALLAHAN: I work in EE and, in the past year, I have been managing ET under the TI office at BPA. We are trying to build a good scanning and screening process. We have a lighting subgroup and a HVAC subgroup. What we are trying to do now is piece the different subgroups together. We have a growing portfolio and a number of research projects we are doing: packaged rooftop, ductless heat pumps, heat pump water heaters. We are doing quite a bit in residential with ductless heat pumps.

REDDOCH: I am in Energy Utilization. The question I want to ask is the following: do we mean energy or electricity? At EPRI, we have a national and international agenda. One of the important things that is revealed in the national agenda is, as you move in different parts of the country, things change quickly. What are the metrics that we need to better understand electricity and energy in the broader sense? EPRI is interested in electricity. We have a large project in transportation.

SMITH: I am the only one that represents an organization that is publicly owned. The perspective I come from is that of a small utility. Utilities are committed to making sure that EE is first in helping us meet our load growth. How does a retail utility leverage resources to better ID ET to help us? Our ratepayers contribute through funding in many of the resources. How does a retail utility leverage ability to forecast? They don't have as many resources. I want to communicate information learned here back home so they can plan better.

HOLMES: I am not in EE. My role is to look at new technologies and new systems. I am working with EPRI in electric transportation. I am also interested in anything that might benefit our ratepayers. When a customer calls up our company and says I have an innovative idea to produce electricity, they forward the call to me. I get all of those calls. We want to identify some of the fundamental research that universities tend to do and give them a little purpose to bring the theoretical research closer to the applied side.

HUSTED: Our needs align with the ones that Todd mentioned. I get calls like Dave Holmes. I am fairly new to EE. I manage the Dealer Channel and that group manages what comes from our trade allies. I always hear statements like, "this is how a utility should be doing it." We run in a two-year funding cycle. We go to UTC and say these are the programs we want to do and this is how much money we need to do them. We are doing CHP, peak demand pilot, and have a heat pump water agenda. We have a community that does not want another substation and our job is to answer the question: how do we avoid it? We have been involved in ductless mini-splits. We are working with Positive Energy Conservation Products on customer behavior. We are involved in coordinating all these efforts. I am pretty excited about it all.

FEDIE: I am the engineering manager or coach in our group. We are helping our customers acquire new technologies and doing the Measurement & Verification to make sure that the benefits and savings are there. We do R&D and we look at ET to keep filling the pipeline.

PENGILLY: I am the research and analysis leader in the EE department

BINUS: I do a three-way split: ET with Ryan and Terry, one-third with NEET (this fits with REETAC, working with Mark and Jeff at NEEA), and one-third in Demand Response. I will be heavily involved in Commercial Demand Response. Ndeye is doing verbatim minutes so we can have WSU do fact checking on the information collected during this workshop.

DAIM: I am a professor of ET at PSU. We focus on Technology Management, Technology Research, and Forecasting. I work on technology validation - tech access. Jisun is graduating this summer. His area is technology transfer.

KIM: I am a PhD candidate at PSU.

Purpose and Overview of Workshop Processes

BRINCH: The purpose of this workshop is to focus on developing the framework for identifying, selecting, and prioritizing high-value, emerging energy efficiency (EE) research, development, and commercialization to be pursued by Northwest organizations and agencies. We have done some of the preliminary discussion in the agenda.

HARRIS: Tom raised a question, what is the scope—EE, for all fuels or just electricity?

OLIVER: I think the focus on electricity for this workshop, but other areas are OK. For BPA, the driver is the regional act. I do not mind if there is a grey area with other sectors outside of electricity, but I don't want to miss electricity in this EE roadmap.

FEDIE: If we look out twenty years, we are saying the act is not changing.

SMITH: Fuel conversion is a grey area. If the gas industry would like to bring funding then we can open the focus.

OLIVER: This tech roadmap might be of interest to others.

HARRIS: What is the scope of end users?

SMITH: Supply-side generation is off the table for now.

REDDOCH: Ten years ago, EPRI had a lot of effort in CHP when gas prices were low. Poor man's CHP is heat recovery.

BINUS: This roadmap is the first draft and it will be a working, living document. We should work with gas companies to attract their funding to go to fuel switching and build on it.

REDDOCH: How does fuel switching play a role in the NW?

OLIVER: The genesis of the regional power act was to change the direction for the need for new power plants. You are not going to use this power act to sell more electricity. You need to push down electricity consumption.

SMITH: Terry discussed a regional perspective. Many of the regional utilities need to recognize that what's happening in the marketplace needs to be taken into consideration. Many utilities need to recognize fuel switching. Don't want to tell utilities what to use but we do want to give them the options available.

HARRIS: We are going to focus on electricity efficiency south of meter; there will be grey edges with other fuels and renewable as it pertains to zero-energy homes. Renewables will also be included. Generation technologies will not be included at this point. If we have a lot of fun doing this EE roadmap, we can do a renewable energy roadmap or even a distribution-level technology roadmap.

OLIVER: BPA's Renewable Energy Roadmap is getting old too. We could re-look at it at some point.

CALLAHAN: There are key drivers on the horizon that will change our roadmap. We will be looking at where we're going, not where we are.

BRINCH: We are going to be looking at products and services that are five, ten, fifteen, and twenty years out. We are going to focus on EE drivers and then have a working lunch. After that, we will discuss products and services for the rest of the afternoon.

SMITH: There are a number of ways of slicing these goals. Can we do it around technologies?

BINUS: This is one of the areas we explored a lot. The way things are explored in the NW is by sector. We can take work out of this roadmap and break it into 4 roadmaps.

SMITH: Something that jumps at me is lighting, do we want to separate residential versus commercial? Should we align technologies instead of customers?

OLIVER: Instead of trying to figure out the technology problem, the first thing to handle is why. We miss that we are trying to solve average energy things. Success has been found by starting to look into why there are problems first.   Want to go top to bottom?

SMITH: Mass market versus customized. In NEEA's early days, a lot of investment was put into customer-unique technologies. Don't want to slice it this way now.

OLIVER: If you go back to the roadmap example, we have tested this many times. It is important.

SMITH: In the past, we have been so boxed in by thinking residential versus commercial that I also think of EE versus Demand.

CURRIER: Later on we can repackage it.

BRINCH: The second workshop is around technology so let's focus on the products and services here.

SMITH: For a retail utility, you are dealing with all the residential, commercial, and all the categories.

REDDOCH: EPRI made a decision to not use the customer sectors bucket; we decided on three buckets: analytics, role of smartness, technologies. With these buckets, we have not forgotten about residential/commercial/industrial and agricultural. If you align your approach to the way money clusters, then it is good. The utilities asked EPRI to fix the issues, but when I ask them for the different buckets for the issues, they have none. You get management to fund certain things by grouping them in categories. We need to figure out a way to fund all the issues.

BINUS: Let's revisit this at the end of the day. Tomorrow we will identify performance goals across each customer sector. We are not setting everything by customer bucket but we wanted to start that way for performance. Breaking into 4 sectors was the original thought. From this workshop, we want to define products and services versus technologies.

BRINCH: Let's look at definitions of products and services and technologies.

BINUS: We put definitions in the packet because we found a constant source of confusion around technology versus products and services.

Workshop Rules of Engagement

BRINCH: (Presented rules of engagement.)

Focus Question # 1

[Given the status of energy efficiency in the Northwest, and what had driven our activities to date, what drivers are expected to impact EE products and services in the next 5-10-20 years within each end-use sector (residential, commercial, industrial, and agriculture)?]

BINUS: We spend a lot of time looking at drivers in all the documents you worked on. We took the top ten drivers. We wanted to acknowledge that you have given us your thoughts.

CALLAHAN: You have on the board drivers that will impact EE Products & Services. Can you specify whose EE products and services you want us to discuss? Are we talking about utilities, manufacturers, or industry?

BRINCH: All.

HARRIS: You need to talk about drivers for the whole market because utilities do not exist in a vacuum.

BRINCH: There are several groups of drivers in your packet. Some drivers are commercial opportunities from the business sector.

REHLEY: *Low Cost Renewable Energy* could be a driver in twenty years. It is a cost and price driver that is common to all sectors.

OLIVER: *$50/ton Carbon* is a climate driver.

HARRIS: *Proliferation of Consumer Electronics* (demand and load).

CURRIER: *National regional cap and trade programs* (policy and target).

CALLAHAN: *Consumer desire to be green*.

SMITH: You should put Jack's under demand and load.

REDDOCH: *Impact of consumer behavior*.

SMITH: *New business interest marketing and selling EE*. Many of the interests will come from Microsoft and Google marketing EE in addition to utilities (before only utilities were marketing EE).

SMITH: Change *Climate change* and make it *Market*.

CALLAHAN: I am constrained by these drivers; there are structural drivers.

DAIM: Do not feel constrained by the driver bucket. Let's just brainstorm.

OLIVER: You can annotate the driver bucket if it is too small.

CALLAHAN: You can annotate the dates also.

SMITH: You can annotate the upper right with category, and the upper left with long term or short term.

HOLMES: We are going to organize them into themes. People do things because it is cheap or some one tells you to do it (legislation). In some point of time, the legislators might say you cannot build a house unless it consumes less than a certain number of kWh per square foot. *Prescriptive Building Permits.*

HUSTED: *Better understanding of behavior modification*.

FEDIE: *Cradle to grave consideration* for Products and Services.

REHLEY: *Increase in available capital for EE*.

OLIVER: *Water Scarcity*.

HARRIS: *Focus on Sustainability* (e.g., net zero homes).

CURRIER: My card says *SG Tech Demos*. I think that technology demonstration will spur change in EE products.

CALLAHAN: *LEED Standards*. It is fascinating to think about the interplay between someone's desire to be green and capturing this desire into a standard. So, is LEED the driver or the follower?

REDDOCH: It is amazing how something today that seems inconsequential gets into a mass scale rollout. What is the next trend that you see? We have a massive explosion of new demand consumer electronics (trends brought forward as a result of mass communication).

SMITH: Is it more energy and resource intensive to print my boarding pass or to have it on my blackberry?

HOLMES: There is no bigger driver for EE than availability. So far we all have instant access. Once there is tighter supply, EE will be necessary to meet electricity demand.

HUSTED: My card is *Common Protocols.* This is similar to Tom. You want appliances to talk to each other and manufacturers. We want manufacturers to understand common communication protocols.

CALLAHAN: I see drivers and needs like two sides of the same coin.

FEDIE: Increased mobility of people and knowledge with electrons combined with increased electrification.

REDDOCH: I agree with Ryan. It is one thing to understand storage technologies pretty well when they are fixed. When they start moving, then they become much more complicated to understand and model.

BRINCH: We have two ideas. The first one is increased electrification. The second is increased mobility of people and knowledge.

CALLAHAN: There is a core idea about the electrification of knowledge. Washington State just built a new data center. It has huge implications.

BINUS: Add increased mobility as a card.

REDDOCH: Electrification of knowledge is a general trend of electrification, period. Instead of us thinking, we are researching information on Google.

OLIVER: We need to differentiate all these drivers and try to not make them too big.

REDDOCH: There is a graph that shows advances of society and use of electricity. The advancement of a society is closely linked to electrification.

REHLEY: *Energy Independence on a Regional Basis.* How do we power our region without buying it from other countries or states? Does that fit into Sustainability?

OLIVER: NIST is doing *SG Interoperability Standards*. This is a near-term driver, six months.

HARRIS: Diffusion of smart capability into all energy-consuming devices.

CURRIER: Changes in transportation energy systems. Transportation as a source for things we want to see in electricity (for example, fuel cells were driven by transportation). There is increasingly interconnectedness of transportation and electricity.

CALLAHAN: Traditionally there are U.S., Asian, and European markets. Social networks are allowing us to see products in another market and pursuing them. Social networking allows us to see products from other regions, changing the decisions people make about purchases. We are going to see more international products.

BRINCH: Individual consumers are changing their behavior as a result of social networking.

BINUS: That sounds like a sub-bullet of *Increased Mobility of People*.

REDDOCH: *DR Ready Star*, like Energy Star.

SMITH: *Changes in the industrial load in the West*. We have a history of aluminum manufacturing and that might change.

HOLMES: Motivation is either money, regulation, or is it human competitive spirit as a driver? My house is more EE than your house.

HUSTED: Consumer awareness of needs. We want to be proactive and not reactive.

FEDIE: How do we adjust our buildings to make employees happy?

PENGILLY: In the agricultural sector, there is a direct tie between commodity prices and electricity prices.

HARRIS: *Increasing focus on Electricity Codes and Standards.*

CALLAHAN: Changes in the retail sector have empowered corporate energy management to be done in the retail sector.

REDDOCH: I think what I heard was Black Friday was really successful but the big surge in sales was Cyber Monday. Do we have a building evolution as a result of ultimate buying mechanisms? Do we have increased warehouse structures?

HARRIS: Electrification allows people to stay at home to save on gas but they are purchasing products, but they could be spending more electricity by shopping online.

HOLMES: Generational change. We think one thing. We do other things but our children will be more proactive with conservation. We can have a technology breakthrough that can take us back to time when the attitude was who cares about the price of electricity. It is cheap so we do not want to conserve energy. I want to add a card titled: Lifestyle changes due to pandemic.

HUSTED: *Improvement in chemical processes* can change EE in the industrial sector.

BINUS: *Demographic shift of consumers*. The entrances of aggregators in the EE world include phone and cable.

CALLAHAN: *Shorter Product Replacement Cycle* is another card.

REDDOCH: This is another electrification application. In Asia, there is a lot of concentrated housing. How do you get garbage there? There is centralized garbage collection. You put them in a bin and a big system sucks all of bags and processes them far away. This replaces the drivers who pick up garbage. There is a lot of *electrification in moving garbage*.

HARRIS: *Uncertainty in fuel prices*. No one can pick a winner that well anymore.

HOLMES: I bought a Toyota Prius because I am worried about fuel prices in the future.

HUSTED: There is potential to have an energy crisis. We dance around it instead of addressing it. Consumer awareness of utility resource needs.

CALLAHAN: The R&D addresses the gaps between needs and technologies.

HARRIS: The exercise here is to find the home for the technologies classified by the driver and then we will think about the technologies.

You can argue whether smart grid is a driver for intelligence for all consumers.

Focus Question # 2

[Given the drivers, what EE products and services are not in the marketplace or are in the marketplace but not widely adopted?]

BINUS: In your packet there are 5-6 pages of EE products and services. We did not want you to give info you already provided. We pulled together some existing product and service groups. In the roadmap, we want to look at products and services that are not available.

BRINCH: We broke it down by sector because that's how they are divided in the power plan.

OLIVER: We need to look at emerging technologies and also technologies that are not available.

HOLMES: We should use "Optics for Logic" instead of "Switches."

GRIST: Yes.

HARRIS: You can find 3-5% savings in better controlling voltage optimization.

HARRIS: We tried subsurface irrigation like Israel but we run into a rodent problem. Subsurface irrigation was eaten by rodents.

GRIST: I was thinking about the future. We have a blind spot in improvements being made in biological components. We can have game-changing technologies. Should we try to advance those nano technologies?

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OLIVER: There is a part of my R&D portfolio that is near term and the other part is longer term and more risky. This region is the number one in EE, so we have excuses to do risky research.

CALLAHAN: We need to have a sharp focus on this risky research or collaborate.

OLIVER: I agree and we collaborate with EPRI. Where do we have interesting challenges of interesting exposure?

HARRIS: What is unique about the NW that will make us use our dollars for this risky research? The NW has a fairly unique climate nationally and we should take advantage of that.

REDDOCH: When we do our prioritization do we consider left or right side (i.e. products and services that are in the marketplace, but not widely adopted or products and services that are not in the marketplace)?

BRINCH: We will give you ten dots, please don't apply more than one dot per card.

HARRIS: The windows can happen in weatherization or new construction. It will probably happen in new construction first.

HARRIS: You can combine *Weatherization* and *Building Design & Performance.*

GRIST: Why are we categorizing?

BRINCH: It is a way to categorize the elements to make the roadmap more effective.

BINUS: We are categorizing because we'll have different swing lanes for *Products and Services* features.

OLIVER: We are categorizing to try to figure out drivers and associated products and services and technologies and R&D needs.

BRINCH: I have a suggestion that between now and the final workshop we categorize with the right buckets.

SMITH: In addition to *Building Design & Performance*, there are energy implications in the way we structure the communities. Do you have a single family home or a condo?

HUSTED: *Residential Air Sealing*.

HARRIS: How do you identify quickly the homes that need air sealing the most?

REDDOCH: The real question is how do I pick the right home to seal without having to test 20 homes of which only 1 really needs to be sealed.

HARRIS: You are chasing the wrong problem. You are trying to insulate the house beyond the need for air ventilation. There is a technology issue.

HUSTED: I hope someone is not just doing one measurement. I hope they are measuring several things.

REDDOCH: We need a card that says EMS that can interact with the Smart Grid.

HARRIS: I added *Easy Consumer Controls*. I mean that you have some way to control everything in your house. It can go under *EMS*.

CALLAHAN: Some of these are short term and long term.

HARRIS: You need to emphasize low-cost *Variable Speed Drives*. They exist now but they are not low cost.

SMITH: Most of this list is of products. We need services.

BRINCH: We will ask WSU to look at existing services gaps.

SMITH: We need to add data centers.

GRIST: There is virtualization.

HARRIS: We need to talk about virtualization of small market sectors.

HOLMES: There is a company called Spray Cool.

Focus Question # 3

[For the top priority product and service gaps identified yesterday, what are the performance goals that need to be established?]

Presentation on Goal Setting:

HARRIS: The next exercise is goal setting in the future. Where do we think these products and services should be in the future? We are looking at stretch goals. If you are thinking of Smart goals, stretch goals can still be specific but they will be more visionary. In both cases, they need to be measurable. You have to come up with some kind of a metric that defines what success would be. The challenge is to come up with a metric for achieving success. The classic example is the 2030 challenge. It is a beautiful example of a visionary goal. It is specific, measurable, and has a 2030 time horizon. You have interim goals. That's a perfect example of the stretch.

The vision of a 2030 challenge is a vision that all new buildings built by 2010 are net zero to net positive. It is a twenty-year target that has been embraced by the architecture community and the

I attended a workshop in San Antonio, 4-5 years ago. There was a presentation on near zero buildings.

REDDOCH: Should we identify stretch goals?

HARRIS: The stretch goal is the end point.

HUSTED: I want to say that there are different goals for new construction.

BRINCH: As you are working on this, please give attention to the high-priority products and services.

FEDIE: Looking at the roadmap example, the visionary goals are to the right and the intermittent goals are to the left in the same swing lane.

BRINCH: I am thinking about technology not widely. You need to pay attention to the market penetration, and move in from the long term into hard core R&D that needs to be done.

REHLEY: Are heat pumps a technology?

CALLAHAN: It is an application and a technology.

HUSTED: Lower heat loss is the point here.

CURRIER: This is where the 2030 goal has some merit. We need goals for new construction and retrofits. What is the strategy set that will move us on the path? Knowledge for product developers? The first 2030 goals are set.

HARRIS: I would encourage people to look at the drivers and try to link the cards to the drivers. On the left side we have all these other drivers. In order to be carbon responsive, we need a high-performance envelope that will not require heating and cooling.

REDDOCH: We always want to keep making technology better. We need to recognize that we have other opportunities in how we deploy the light. SS lighting does not have the same coverage as CFLs. I put lighting in structures that look at smartness. There are gains in the system approach.

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HARRIS: Smart device level controls can be applied across our buckets. Do we have services that apply to all end-user appliances?

CURRIER: When you tie it back to the drivers, you will have things that desire comfort, what is the impact on energy use of all the drivers? We are assuming that energy use will go down. What do we want to know that makes sure that these innovations support our goals?

BRINCH: More of this discussion can happen, time is pretty limited. The first order of business is to identify how you will self-select.

HARRIS: Do you want to explain one of the performance goals sheets? We will pass them on.

The top level, reading "EE performance goals," you might put Water Heating.

Break Out Reports

[More information is included in the Workshop Proceedings Report]

Group # 1

HUSTED, PENGILLY, DEGENS
Building Design/Envelope for Retrofit

HUSTED: The first thing we needed to identify was new construction versus retro (old) construction. We looked at gaps and needs for zero energy homes. We looked at code changes. Long term, all new construction, and zero energy by 2030. By 2015, we want homes that are 50% better than all net zero.

CURRIER: You are saying that codes will change and you need them to align.

HUSTED: I have a lot of areas that are blank. For deep retrofits, we need better data on what energy savings we can get out of it. Product development, certification, and branding. By 2030, 50% less energy consumption; 2020, 10% of market would see 30% savings. We had another category called "labeling," determine what it is. By 2011, we want labeling consensus.

DEGENS: You only have to meet the standards at the point of sale, like in Europe. We are doing that in Texas already.

New Construction: A lot of the same things apply. 2030, net zero label. 2020, labeling mandatory. Coming up with different labels diminishes the brand. Different labels mean different things (Energy Star, green seal, LEED).

DEGENS: We have many labels nowadays. He cited examples: lower cost technology.
High Efficiency windows there is nothing that identifies. We need better labeling. 2012, increase in window codes and by 2015, switchable windows with PV capabilities—20% of the market. Skylights becoming an alternative for light.

Roofs: Technology, price, and standards are gaps. Distribution and adoption. Easy to install. 2015 products locally available, building integrated PV. 2030 code.

For retrofit insulation, need for training and awareness of consumers. Methods and technologies, identification of needs and low cost, make easy to install. Even the contractors do not like bidding it. We went to mobile homes. For new construction, insulation and better modeling technology.

Effective insulating shades: Better products and awareness were the gaps. You want infrared to become standard in the building industry.

DEGENS: When you do the labeling, infrared might be part of the goals. We are hoping that the standards will help with that.

HUSTED: We have 2015 goals and so on. We felt that insulated manufactured homes were very important. We do not have to confirm the same codes as everybody else. This gets in the HVAC market and do retrofit. Next Steps: Data, data, data…pilots and more.

Group # 2

HARRIS, SMITH, FEDIE
Hot Water and HVAC

Hot Water

HARRIS: Hot water and HVAC. We took a little time to add information on the cards.

Hot Water: The solution needs to be low first cost and have the same level of comfort for the consumer. Reliable, comfortable, and convenient; low maintenance, heat recovery. Provide same level of convenience. Interactive controls and smart controls. We came up with low carbon, sustainable high efficiency water heating.

Need codes and standards for water heaters; by 2030, the whole stock should be replaced with the new systems. They need to deliver amenity level required by the consumer if the consumer needs a certain amount. The system cannot be an inconvenience for the adopter. The third goal is net zero or positive producing energy. It has to have storage capability, to store energy from other systems. It also needs a heat recovery integration system.

LEDBETTER: Heat recovery ventilation is another option.

HARRIS: I never thought of net zero water heaters before, so I find it quite challenging. The Japanese CO2 water heaters are sold with solar panels. It is a matter of sizing the PV array. It is not out. What can you do with thermal storage with the hot water, is another option. These systems need to be cost effective. Hot water usage is matched to the need. Both in quantity and quality, you do not need 100 degrees water. The hot water system is matched with need in quantity and quality.

Goal number seven would be wastewater heat recovery or no more turning on hot water. We did not talk about water conservation, but this is as important. System needs to determine how much water is needed. We can do re-circulated hot water to lower water loss but that would consume more energy. It would be coordinated with all other appliances so they do not all have strip heat. Strip heating is moving downwards.

The short-term goals discussed storage tanks, of having ultra low loss thermal storage. You can exchange materials and do high density stuff. You need an annual. This is a 5-year goal. They need to have DR and SG to absorb excess wind energy.

Medium Term: 60% savings or more compared to today. Better grab heat out of it before it leaves site. Waste heat recovery with no heat left behind to move towards the idea of net zero homes.

SMITH: We tried to look at it from the customer point of view and the utility point of view. It raised the issue of water quality. We talked about having some onsite water recovery and adding various rates of filtration so you have water with different filtration levels for the lawn and the washing machines.

HARRIS: If there is going to be a system that aggregates rainwater for treatment, it provides a dedicated place for heat recovery.

SMITH: No water that leaves the site would have hot water.

HARRIS: Not heat left behind.

Oregon trust: How does gas fit into that?

HARRIS: If gas was a supplemental unit, you would have off-set. All the same stuff would apply in terms of storage and thermal recovery. You can have methane as the source of heat for water heating.

LEDBETTER: Did you talk about efficient water distribution?

HARRIS: We talked about it at the end use level. We talked about moving the heat pump to the pipe. The pipe is coated with micro grid heat pumps.

LEDBETTER: My guys do a lot of work in micro heat pumps for military applications.

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HVAC

HARRIS: We looked at drivers and needs to have a comprehensive set. As we have an aging population we need more comfort.

PENGILLY: Increase comfort ID cross generation.

HARRIS: Read all the drivers: net zero buildings, demand in reduction in zero intensity.
Gaps: One of my anecdotes is that my car is smarter than your building. Buildings do not have technicians that go on the roof with computers. We currently do not have on-board diagnostics. We do not have good data streams. The HVAC is not tied to the building. There is no feed band between the building. We do not optimize use of ambient conditions. We spent a lot of energy to distribute staff. It is all about moving air.

FEDIE: We focused on hot water heater and roof HVAC in the NW.

Group # Three

LEDBETTER, REDDOCH, REHLEY
Electronics and Lighting

[REDDOCH stated that the way we are getting quality is to crank up project development.]

LEDBETTER: On this problem that confronts all electronic devices sold, the cell phone industry has a nice model to creating a pathway. For example, the power supply for changing the battery. The changes they require is to separate the charger from the cell phone. If you did the same things for electronics, it creates a pathway for a DC power system infrastructure.

HARRIS: Can we create a DC inf. on top of 120 VAC?

REDDOCH: NESC will prevent that.

HARRIS: Smart breaker family that can deliver AC or DC.

REDDOCH: We are making really big process with smart solar panels.

[LEDBETTER presented lighting.]

LEDBETTER: By 2030, 80% goal reduction in new buildings. Achieved through several pathways:

1. More efficient sources – solid state lighting. Reduce cost and increase efficiency.

2. More and better lumens – color stability, improved lumen, task ambient light levels. In certain areas of a room, the lights go dim where they are not needed. Lights with sensors on them track people where they are going. For outdoor lighting, we need to do a better job of rewarding manufacturers for better designed luminaires, how the lighting is distributed.

3. Better application of luminaires-controls. 15% of 80% total from improved apps. 50% from lighting controls.

4. Maximize use of daylight

5. Training and education. Some people are mis-applying SS lighting. DOE is working on helping to prevent this.

SMITH: What about LED and stimulus funding?

LEDBETTER: We are forming a consortium of municipalities to make them adopt best practices in choosing products [and to] better understand the technologies and the peculiarities of each technology.

SMITH: What about manufacturers?

LEDBETTER: The LED manufacturers understand semiconductors, but they do not understand lighting.

GRIST: One of the missing elements is a buyer's agent. Given that there is a plethora of new manufacturers, DOE can be a buying agent. The lighting designers have no EE goals.

LEDBETTER: We are hosting a municipal lighting consortium. They can have a common specification that they can use to order LEDs from the manufacturers. We are doing it for a number of large customers.

CURRIER: We have other communities buying lighting in the next 6 months. Are there websites they visit to learn additional facts about LEDs?

LEDBETTER: There is a series of technical lighting. There is one specifically on outdoor SSL. We have to have the municipality consortium running in a month. We announced this many, many months ago.

DEGINS: There is the list on lightfacts.com. You can look at that too.

CALLAHAN: These are enabling technologies. What got clustered were sensors and electric power meters. The grouping we did was devices: real time smart electric power measurement, the easy interface between people and control.

Group 4

CALLAHAN, CURRIER, HOLMES
Sensors, Meters

CALLAHAN: These are enabling technologies. Meters mean electric power. We didn't do much with EMS.

Electronics. We thought broadly about all electrical devices, consumer energy management services, and low-cost savings verification techniques.

Smart device level controls. Many systems are uncontrolled. They are "on" but nobody is home. Could add sensors, smart strips, but they are expensive; central energy management control has been discussed; electric devices are dumb.

Goals. Spread out occupancy sensors and make more widespread. Long-term goal is modular generics. Medium term is to extend to HVAC. Need easy simple controls that allow large number of devices to be linked, matched with a level of sophistication.

Low-cost savings verification techniques. It is difficult to quantify energy saving.

Closing

BRINCH: We made good progress over the last two days. This workshop will use hatch mark cards for Workshop Three. No hatch mark cards will be used for Workshop Two. We are thinking of January 20-21 for workshops 2 and 3 and February 5 for the fourth workshop.

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Building Design and Performance				
Zero energy practical, cost-effective home designs	Not in marketplace	◆	technical & market	2 to 5 years to become practical; 5 to 10 years to become cost-effective. Need systems approach including tech integration + enhanced market pull.
Building labeling - energy, water, waste	Not in marketplace	◆	market	May exist in EU; build on HERS or LEED certification
Transformative building materials - envelope reacts to environment and loads	Not in marketplace	◆	technical & other	10 plus years to significant market penetration. Need further development of technologies, systems approaches, and building industry uptake.
Deep retrofits - commercial, residential	In marketplace	◆	technical & market	3 to 10 years to become cost-effective. Need market pull by consumers, building industry, contractors, and communities.
Community master planning	In marketplace	◆	market	Need market pull by governments, real estate developers, builders.
Integrated building design (= advanced efficiency and productivity and understanding 1st cost) (commercial) (N)	In marketplace		other & technical	Building America (U.S. DOE); Savings By Design (California IOUs). Need more user-friendly modeling tools and integration.
Fully passive buildings for Net-Zero	Not in marketplace		technical, market & other	5 to 10 years to become practical; 10 to 15 years to become cost-effective. Need systems approach, tech and industry integration.
Building Envelope				
Net energy producing windows	Not in marketplace	◆◆◆◆	technical	Less than 2 years for PV-integrated windows to enter market at meaningful scale
High efficiency windows - more than double pane	In marketplace	◆◆◆	technical & market	Need new technology, market pull to drive costs down.
Advanced roofing materials	In marketplace	◆◆	technical & market	Need better materials w/improved performance at lower cost; increased roofing industry acceptance and advocacy, market pull.
- Absorb	Not in marketplace		technical	
- Reflect	In marketplace		technical & market	
Residential shell upgrades (more products/systems) - easy/cheap?	??	◆◆	technical & market	Need clear definition to assess this Product / Service
Infrared scanning services	In marketplace	◆	market	Need increased market pull and availability, reduced cost
Foam wall insulation	In marketplace	◆	technical	Need cheap, convenient, environmentally-benign materials

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Window frame improvement - commercial	Not in marketplace	◆	technical & market	2 to 5 years to enter market at meaningful scale: driven by NFRC proceedings and industry buy-in. Need cheaper, better-performing, long-lived materials and market pull.
Non-utility weatherization funding	In marketplace	◆	market	U.S. DOE (w/ARRA funds) & HUD are providing; not clear if this funding is sustainable. Need lead agencies to drive long-term uptake.
Cost-effective residential air sealing - retrofits and M&V *[placeholder for Fred Gordon suggestion to include Duct Ninjas - does he mean training protocols?]*	In marketplace		technical & market	Need technology improvement to reduce costs; increased market pull
Effective insulated window shades	In marketplace		marketing	Need increased market pull and availability, reduced cost
Water Heating				
Ductless heat pump with water heating capability	Not in marketplace	◆◆◆◆◆◆◆	technical & market	Could enter market in 5 to 10 years with R&D and product development push. Need reliable, cheap, easy-to-install technology and market pull to engage manufacturers in production.
Heat pump water heaters with exhaust vent	In marketplace	◆	market & technical	Need increased market pull and availability, reduced cost
Solar DHW for commercial / residential applications	In marketplace	Added	market & technical	Need increased market pull and availability, reduced cost. Must be driven by roofing and building industry to achieve broad acceptance.
HVAC				
Self-diagnosing, self-healing HVAC systems	Not in marketplace	◆◆◆◆◆	technical & market	Likely to enter market in 3 to 5 years due to California CPUC HVAC initiatives. Need reliable, cheap technology that integrates with existing equipment and achieves HVAC industry acceptance and uptake.
Commercial variable refrigeration flow	In marketplace	◆◆◆	technical & market	Need technology improvement to reduce costs and ease of application, better documentation of energy savings; increased market pull
Geothermal heat pump for residential and commercial use	In marketplace	◆◆	market & technical	Need increased market pull and availability, reduced cost

Technology Domain / Products & Services	**Market Status**	**Roadmap Team Vote**	**Primary Barriers**	**Notes - including barrier details**
Solid state cooling	Not in marketplace*	◆◆	technical	*Actually in the marketplace at a very high price. This is a thermoelectric cell run in reverse. Need radical materials advances to achieve cost parity with other technologies.
Non-vapor compression cooling systems (50%<)	In marketplace	◆◆	technical & market	Need technology improvements to improve performance under peak temperature and humidity regimes; industry acceptance and uptake. Not currently accepted by mainstream HVAC industry.
- Desiccant cooling	In marketplace	Added	technical	Need cheap, convenient, environmentally-benign materials, no entrainment of fluid into air stream
CO2 refrigeration or other alternative refrigerants	In marketplace	◆	technical & market	Some products & equipment entering the marketplace in Asia. More alternatives and compatible equipment needed. Also need market pull in U.S. to drive adoption.
Simple, effective demand controlled ventilation	Not in marketplace	◆	technical & market	Sensors for non-CO2 indoor pollutants may lead to greater market penetration by this technology in 3 to 5 years. Also need market pull, industry advocacy.
Distinct heating and cooling	In marketplace		market & technical	Market penetration inked to community master planning
Residential reverse cycle chiller	In marketplace		technical & market	Need better performing, more reliable equipment at reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance.
Low temperature air source heat pumps	In marketplace		market & technical	Need increased market pull and availability, reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance.
In-floor heating/cooling (electrically driven) - with fluid	In marketplace		market & technical	Need increased market pull and availability, reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance.
Demand-controlled ventilation for commercial kitchen stove hoods	In marketplace	Added	market & technical	Need increased market pull and availability, reduced cost. Must be driven by local governments & industry to achieve broad acceptance.
Appliances and HVAC equipment with low or no standby load	Not in marketplace	Added	technical & market	Need technology improvements, market pull

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Inverter-driven residential whole house AC and heat pumps	Not in marketplace	Added	technical & market	Need technology improvements, cost reductions, market pull. Appears to exist in some Australian products.
Direct/indirect evap precooler for large 24/7 load (e.g. hospitals and data centers)	Not in marketplace	Added	technical & market	Need large scale, highly reliable equipment at reduced cost and with well-understood maintenance cost. Must be driven by end-users and institutional / data center construction industry to achieve broad acceptance.
Lighting				
Solid state lights	In marketplace	◆◆◆◆◆◆◆◆	technical & market	Primary technical & market barriers are reflected in Haitz' Law - lamp performance improving 30X and cost decreasing 10X every ten years.
User movable lighting fixtures (e.g., in office drop ceiling) and controllable	Not in marketplace	◆◆	market & technical	Need a champion and a technical / market initiative to advance this. Can achieve significant market penetration in 2 to 5 years.
Dimming, controlled street area light	Not in marketplace	◆◆	technical & market	Need better sensors, controls, and system logic to meet safety and security requirements. Must be driven by government agencies & industry to achieve broad acceptance.
Efficient metal halide fluorescent fixtures	In marketplace	◆◆	market & technical	Need increased market pull and availability, reduced cost. Must be driven by lighting manufacturers, specifiers and contractors to achieve broad acceptance.
Residential/commercial paintable OLED	Not in marketplace	◆	technical	OLEDs should reach the general illumination market in 3 to 5 years. OLEDs applied as paint-on products may be feasible in 10 to 20 years.
Optimized - lighting design fixture tube ballast layout and controls - complement to new fluorescent standards	Not in marketplace	◆	other & technical	2 to 3 years to achieve significant market penetration. Need integration of existing components and practices to address current and emerging needs.
Mesotopic lighting for streetlighting.	Not in marketplace	Added	market & technical	Achievable with sufficient market pull. LED streetlights are well-suited to this application and will probably fulfill this objective with modest encouragement by the lighting design and specifier community.

Technology Domain / Products & Services	**Market Status**	**Roadmap Team Vote**	**Primary Barriers**	**Notes - including barrier details**
Electronics				
Data centers	In marketplace	◆◆◆◆	other & technical	Need IT and data system specialists to align their activities with those of facility design, operation & management specialists.
Virtualization and consolidation of small system	In marketplace		technical & market	Need better systems & system management applications to meet reliability and security requirements. Must be driven by client, industry, and government agencies' requirement to achieve broad acceptance.
HVAC *(also see direct/indirect evaporative cooler in HVAC section above)*	In marketplace		market	Need market pull by clients', industry, and government agencies' requirement to achieve broad acceptance.
Power conversion	In marketplace		technical & market	Need improved system performance & integration with / into data center hardware to meet reliability and energy savings requirements. Must be driven by client, industry, and government agencies' requirement to achieve broad acceptance.
Environmental interlocks - hotel key locks	In marketplace	◆◆◆◆	market	Need broad industry awareness of system performance and benefits to drive market pull.
Smart strips - turn off appliances when not being used	In marketplace		technical & market	Need improved system performance & integration into home & office hardware. Must be driven by customers', commercial facilities' and government agencies' requirement to achieve broad acceptance.
Alarms/buzzers "indicators" when meet energy use threshold	In marketplace		technical & market	Need improved system performance & integration into home & office hardware. Must be driven by customers', commercial facilities' and government agencies' requirement to achieve broad acceptance.
Alt: pre-paid metering	In marketplace		other & technical	Must be driven by utilities', regulators', and customers' interests and requirements.
Optical computing	Not in marketplace		technical	Not yet commercialized, good promise for commercialization in 2 to 5 years. Energy savings has not been a primary driver for this product.
Cradle to grave design	In marketplace		market & other	Needs market pull by consumers, government agencies and designers to achieve broad acceptance and adoption.
Electronics	In marketplace			
Sustainability	In marketplace			

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Large-area video displays <10 watts	Not in marketplace		other	Likely technology will be AMOLED - expect 15+ years to achieve below 5 Watts/ft2. Barrier is industry association opposition to low energy products.
Projector or head gear computer/TV displays	Not in marketplace		technical & market	A perennial favorite of ubiquitous computing researchers. Hand-held projectors are coming very soon - 12 to 24 months. Head gear displays will require technology development for usability and reduced costs.
Switch to turn off all home electronics without disrupting software	Not in marketplace		market & technical	Need a champion and a technical / market initiative to advance this, then integration into electronics. Can achieve significant market penetration in 2 to 5 years.
Efficient home electronics	In marketplace	Added	technical & market	Need improved subsystems & integration into products. Must be driven by customers', retailers' and government agencies' requirement to achieve broad implementation.
Regulatory				
Code compliance	In marketplace	◆◆	other	Need alignment of government plus utilities and/or NGOs to drive initiatives. Public support or acceptance is vital. California is active in this domain.
Education	In marketplace		other	Need engagement of government plus NGOs and/or utilities to drive initiatives. Public support or acceptance is vital.
Workforce	In marketplace		other	Not sure what this refers to - perhaps the need to expand the code-compliance workforce?
Time of sale EE upgrade requirement	In marketplace	◆◆	market & other	Exists on a pilot basis in some jurisdictions such as Burlington, VT. Need engagement of government and real estate industry to drive initiatives. Public support or acceptance is vital.
Performance based energy codes	In marketplace	◆	other	Need alignment of government plus building industry, plus utilities and/or NGOs to drive initiatives. Public support or acceptance is vital. California is active in this domain.
Point-of-sale EE/DR products for electric vehicles utility - auto dealer	Not in marketplace		technical, market, other	Dependent on utility - auto manufacturer coordination (getting elephants to dance). Need significant technology and infrastructure development. Expect 10+ years to for meaningful market penetration.

Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Rate design for ancillary services	In marketplace		other & market	Exists on a pilot basis for some services. Need utility, regulatory, customer engagement to achieve market penetration. Energy efficiency has not been the primary driver of this service in the past.
Efficiency standards for laboratory and hospital equipment	Not in marketplace	Added	market	Must be driven by universities & industry in concert with regulatory agencies. This opportunity may be comparable to data center efficiency.
Appliances				
Efficient block heaters	Not in marketplace	◆◆	market & technical	Need a champion and a technical / market initiative to advance this. Can achieve significant market penetration in 2 to 5 years.
Control				
Circulation				
Wireless homes	In marketplace		technical & market	Assuming this means wireless control, not wireless power distribution. Needs technology development, market pull by consumers, builders, and appliance manufacturers.
Applications for refurbished electric vehicle batteries	Not in marketplace		market & technical	Need a champion and a technical / market initiative to advance this.
(Ultra Efficient) Car Chargers	In marketplace		technical & market	Need improved system performance & integration into vehicles, charging stations, and residential infrastructure. Must be driven by customers', auto manufacturers', commercial facilities' and government agencies' requirement to achieve broad acceptance.
Heat pump clothes dryer	Not in marketplace	Added	technical & market	Need a champion and a technical / market initiative to advance this. European models are slow and expensive, unlikely to penetrate U.S. market. U.S. prototyping by TIAX appears stalled - no public information since 2006.

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Other				
Industrial large commercial voltage/electric system optimize	In marketplace	◆◆◆◆◆◆	market & other	In market but for custom applications only. Not clear how cost effective this can be on the average, and how it fares relative to other energy efficiency retrofits at the same cost.
Consumer education - certification	In marketplace	◆	market & other	Need engagement of government plus NGOs and/or utilities to drive initiatives. Public support or acceptance is vital.
Low pressure pump irrigation (Agriculture), existing but not sufficient	In marketplace		market & other	Need engagement of ag industry, service providers & government to drive initiatives.
Low air-flow laboratory fume hoods	In marketplace	Added	market	Must be driven by health & safety regulatory agencies in concert with universities & industry.
Quality assurance and commissioning	In marketplace	Added	market & technical	Need alignment of government plus building industry, property management companies, building owners, as well utilities and other intermediaries to drive initiatives. Public support or acceptance is vital. California is active in this domain.
Water - energy efficiency initiatives	In marketplace	Added	market & technical	Need alignment of government plus water agencies, as well utilities and other intermediaries to drive initiatives. Public support or acceptance is vital.
EMS				
Low-cost EE savings verification techniques	In marketplace	◆◆◆◆◆	technical & other	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 18 to 36 months. Barrier is development and integration of verification technologies into systems and products, plus lack of market pull by utilities and other EE stakeholders.
Easy/simple consumer (user) controls	In marketplace	◆◆◆	technical & market	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on.

Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Consumer energy management service(s)	In marketplace	◆◆	market	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on.
Industrial energy optimization	In marketplace	◆	technical & market	Pilot and special cases at present. 3 to 5 years for greater market penetration & ease of use. Barrier is development of highly reliable, low-cost technologies, plus market pull for their development.
EMS that can interact with the Smart Grid	In marketplace		other & technical	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on.
Sensors and Meters				
Smart device level controls responsive to user and environment	In marketplace	◆◆◆◆◆	technical & market	Entering the market now. Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on.
Residential occupancy sensors	In marketplace	◆	market & other	Need market pull by builders and remodelers, consumer & government advocacy to drive greater diffusion & adoption.
Air quality sensors control ventilation	In marketplace	◆◆◆◆	technical & market	Need market pull & industry advocacy to drive greater diffusion & adoption.
Inexpensive end-use load monitoring	In marketplace	◆◆◆	technical & other	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 18 to 36 months. Barrier is standard architectures for these to operate in / on.
Real time consumption by appliance	In marketplace	◆◆	technical & other	Current systems are complex and unreliable. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier has been development of real-time energy signature recognition for specific appliances & systems.
New commercial building electric metering, measurement protocols, and benchmarks		◆◆	other	Need clear definition to assess this Product / Service
Smart utility meters for all customers	In marketplace	◆	other	Entering the market now. Barrier is utility & regulatory engagement

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Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
Smart charging recharging	In marketplace		technical & market	Need improved system performance & integration into vehicles, charging stations, and residential infrastructure. Must be driven by customers', auto manufacturers', commercial facilities' and government agencies' requirement to achieve broad acceptance.
Machine Drives				
Low cost residential heat recovery system (fans)	In marketplace	◆◆	market & other	Most cost effective in cold climates, so Canada and Scandinavia have been active in this technology since the 1980s. New heat exchanger designs may expand U.S. market penetration in 3 - 5 years.
Low-cost, variable speed motors for small appliances	In marketplace	◆◆	technical & market	In market- need further development of products for a broad range of applications at reduced cost.
Smart Grid friendly adjustable speed drives	Not in marketplace		other & technical	Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on.
Adjustable speed drives for small power movers	In marketplace			How is this different from Line 110? Should this be "power mowers"?
Waste Energy Recovery and CHP				
Waste energy recovery	In marketplace	◆◆	technical & market	Need expanded development of products, support infrastructure for design, installation, and maintenance; market pull by potential customers segments.
Water, sewage	In marketplace		other	Need financial drivers for water & wastewater utilities, market pull and government advocacy.
CHP	In marketplace	◆	other & technical	Barriers include emission impacts and lack of robust maintenance infrastructure.

Energy Efficiency Performance Goals Building Design/Envelope for Retrofit (Retro)			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Deep Retrofits for Residential/Commercial	• Awareness/training/technology • Easier methods to determine needs, financing, product development, codes and enforcement certification and branding • Non-utility weatherization funding	• 2015 – 5% of market 30% savings • 2020 – 10% of market 30% savings half those 50% or better • 2030 – 50% less energy consumption	• Design & analysis tools to integrate components and predict whole-system energy performance
Labeling	• Determine what it is • Get stakeholders to adopt • Develop national/regional stakeholder • Strong branding	• 2011 – consensus on labels • 2015 – 20% of homes meet standard • 2020 – mandatory	• Energy benchmarking tools • Data aggregation systems
Retro and NC Windows	• Lower cost/better technology • Design – education training • Code national/regional (day lighting) specs • Better labeling • Shift industry focus from residential to commercial performance standards – esp. superior frames and whole window performance • Concepts for next generation “same R-value as a wall” or ZNE windows • Electrochromic issues such as cost, life, performance • Address seamless PV integration into fenestration	• 2012 – increase window codes residential and commercial • 2015 – switchable window/PV 5% of replacement market • 2020 – residential envelope performance standards • 2030 – net energy producing 50% market • Skylights become alternative for lighting	• Next-gen coatings for triple-glazed IGs with superior SHGC and U-factor ratings • Integral low-E and PV windows • Self-powered electrochromic-PV windows
Transformative Building Materials	• Prefab components for low-cost ZNE construction • Make it easy for inexperienced workers to build right • Reduce carbon footprint of typical materials	•	• Modular, pre-insulated wall, floor, and ceiling units
Solar/Smart Roofing	• Technology/price/standards • Distribution/adoption • Local restrictions • Data/easy to install	• 2015 products readily available in marketplace at a low cost • 2020 – intelligent buildings with PV • 2030 – buildings codes that required solar	• Modular PV installation systems, including electronics • Cool / PV / DHW heater roofing
Retrofit Insulation	• Training/methods and technologies • Awareness – identification of need at a low cost, easier to install • *See IR scanning in NC section below*	•	• Insulation optimization via IR scanning & analysis software • Community aerial IR scan + GPS data systems

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Energy Efficiency Performance Goals

Building Design/Envelope for Retrofit (Retro)

Energy Efficiency Product & Service Area	Gaps/Needs	Performance Goals – Short (S), Medium (M), Long (L) Term	Gap-filling technologies
New Construction Insulation *– should be in NC section below*	• Better modeling/technology • Modular homes • Better materials with higher EE value • Easier to install	•	• Insulation optimization via IR scanning & analysis software •
Effective Insulated Shades	• Better product/awareness • Aesthetically appealing	•	• New materials for thin, super-insulating fabrics • Window-integrated insulating shades (built-in not added on) • PV-integrated window shades

ENERGY EFFICIENCY PERFORMANCE GOALS

BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)

Energy Efficiency Product & Service Area	Gaps/Needs	Performance Goals – Short (s), Medium (M), Long (L) Term	Gap-filling technologies
Net Zero Energy Home	• Effective design • New technology • Education and training • Code change • Encouraging high density • Architect and engineers, installers, code/manufacturing • Branding urban areas and certification/commissioning	• 2015 – All new construction zero energy by 2030 • 5% – 50% better than code • 2020 – 20% - 50% or better of that 50% are net zero after that code	• Design & analysis tools to integrate components and predict whole-system energy performance
Labeling	• Determine what it is • Get stakeholders to adopt • Develop national/regional agenda	• 2011 – have labels • 2015 – 20% are using labels • 2020 – labeling mandatory increasing to meet zero energy • 2030 – Net zero label	• Energy benchmarking tools • Data aggregation systems
Retro & NC Air Sealing	• Data better/methods • Training improvements in identifying	•	• Next-gen substitute for blower door testing – cheap & easy
Eliminating Home Penetrations	• Better designs • Codes/products/technology • Training	•	• Modular, pre-insulated wall, floor, and ceiling units
IR Scanning	• Lower cost/more awareness • Identifying need at a lower cost – part of labeling • Similar to car facts	• 2015 – cheap products widely available realtors/ contractors • 2020 – thermal overlay major meter areas	• Insulation optimization via IR scanning & analysis software • Community aerial IR scan + GPS data systems
Day Lighting Walls	• Measurable • *Not sure what this means – refer back to proposer in Workshop 1*	•	•
Manufactured	• Follow codes/code improvement • Retro structurally engineered • Panels that can easily installed – spray on • Elimination of duct work	•	• Modular, pre-insulated wall, floor, and ceiling units Modular, pre-insulated wall, floor, and ceiling units

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ENERGY EFFICIENCY PERFORMANCE GOALS LIGHTING			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Lighting	• Optimized design of lamp, ballast / driver, luminaire, controls for ease of installation, operation, maintenance • Optimize use of fluorescent, SSL, halogen IR technologies by application	• 80% reduction in avg. lighting electric use in new buildings (through combination of more efficient light sources, more efficient luminaires, better controls, better application, and more use of natural light (L)	• Hybrid fluorescent / SSL technologies for optimum performance, cost & aesthetics
SSL	• Reduce cost • Increase efficiency • Improve stability over time • Better CRI • Better understanding by lighting professionals • Improve lumen maintenance	• 200 lm/W for 3500 CCT (use DOE Roadmap #s) (50% of 180% goal) (L) • Demonstrations • Training/education • Target early, cost-effective applications	• Super-SSL – next generation L-prize winner meeting all needs identified in Gaps column
Improve Task/Ambient Application	• Better user control of task lighting, including user-moveable luminaires • Ability to have task lighting quantifiable reduce overall light levels and lighting energy consumption	• (15% of 80% goals) Establish as standard practice: reduced ambient light levels coupled with increased use of task lighting (L) • Codes • Training/education	• User-aware controls that reduce ambient levels for task and energy optimization
Lighting Controls (Dimming, OC Sensors)	• Cheaper controls • More reliable controls • Training and education • Better human interface	• 50% reduction (25% of 80% goal) (L)	• Improved sensing technology to make controls more natural for users (poss. military-derived)
More Efficient Luminaries	• Market needs to be rewarded for efficient luminaries • Change common metrics from source efficacy to luminaire efficacy • Use FTE ***[what is this?]*** for outdoor lighting	• In residential sector, begin shifting emphasis from efficient sources, to efficient luminaires	• Metrics for light delivered, task and aesthetic performance, not light emitted
Day Lighting	• More responsive controls, esp. for	•	• Next gen ambient

	ting • Easier to design, commission and operate • Better light quality as perceived by users		trols

Energy Efficiency Performance Goals Electronics			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Sleep Mode	• Retain intelligence • Capability to restore to full functionality • Responsive to user needs and preferences • Minimal user interaction required	• Require sleep mode features that reduce energy usage by 90% (S-M) • Work with manufacturing community as in trade associations and interest groups	• User –sensing and user-aware controls • Sleep-mode chip or equivalent design standard
DC Power Source	• Lack of DC network infrastructure • Access to DC powered end use • Evidence that DC has predictable energy savings benefits compared to AC, and under what conditions	• Develop access to DC power sources to simplify AC/DC conversions and reduce losses (M-L) • Work with state/local entities to invoke codes and standards	• Standard DC system products for voltage conversion, facility level distribution and device connection
Use and Virtualization	• Standard calculation methods to predict savings • Standard approaches to maintain reliability and performance with reduced energy use	• Create advanced internal (to the device) energy management systems (virtualization) to reduce energy usage (M)	•
Component Level Efficiency	• Disclosure by component and system manufacturers of how interactive effects increase or cancel out energy savings	• Development of low loss components for electric devices (example: substitute LED lighting for fluorescent back light in LDCD TW) (M)	• Tools for modeling component interactive energy impacts
Complete Electronic System	• Needs an interface to the smart grid feature • Turn off all home electronics w/o disrupting functionality – smart strip equivalent software or chip that can be built into any product • Make saving energy without sacrificing user experience a CEO goal	• Reduction of 50% in energy usage based on today's performance (M)	• Benchmark high-performance (energy and user experience) products in each category – e.g., TVs, video games, DVRs, etc.
Interlock Devices to Manage Energy Use	• Convenient not inconvenient for users • Designed in, not added on to systems	• Develop low cost systems that permit "quick" adoption (S) • Provide incentives to help bring devices to market	• Standard interlock systems & components available to OEMs for their products

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Energy Efficiency Performance Goals **Heating, Ventilation, and Air Conditioning (HVAC)**			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Low-carbon, sustainable, high-efficiency products and systems that automatically diagnose, predict, and maintain high efficiency throughout the product life cycle without sacrificing amenity or service delivery	• Trained technicians (hopefully not needed as much) • Don't currently have "on-board" diagnostics or data streams to collect • Don't have redundant or corrective hardware • Not tied to building needs/loads • Doesn't communicate (2-way) well with building controls relative to performance issues in equipment and systems • Don't currently optimize use of ambient or indoor conditions, e.g., economizer, indoor ventilation controls, heat recovery • Current high-energy use for distribution of heat and cooling beyond actual vent need	• 100% of new construction self-diagnosing controls for the packaged HVAC unit (S) • Predictive maintenance in 100% of new sales (S) • Economizer controls & systems (seals, actuators, dampers) that are reliable & effective (S) • Functional performance test definition for factory testing (S) • Variable speed control on ALL systems, fans, compressors, pumps, etc. (S) • Ventilation/temperature/humidity delivery matched to actual uses at granular level so controls can be designed appropriately with monitoring (M) • Intelligent controls connected/communicating with buildings & spaces so unit delivers only what spaces need (M) • Predictive controls to optimize operation (M) • Initial self-healing/correcting (M) • Pattern recognition/learning system (M) • Non-vapor compression cooling (S.S. or Evaporative) (L) • Packaged equipment (up to 20 tons capacity) for 100% of new construction, to capture all lost opportunities in the new and replacement market (L) • Controls to meet indoor air needs – no excess vented air beyond occupant needs (L) • Delivery of only what the space of occupant needs (L) • Intelligent Systems with predictive, diagnostic controls & self-healing processes (L) • Maximum efficient distribution of HVAC (don't use ducts if you don't need them) (L) • Work with manufacturing community as in trade associations and interest groups	• User-aware & self-diagnosing controls for the packaged HVAC unit • Predictive maintenance • Reliable & effective economizers controls & systems • Variable speed everything with low cost, high reliability • Fast, accurate controls for enthalpy and air flow • Wireless controls that meet or exceed all standards for wired controls • Hybrid vapor compression / evap cooling systems and sub-systems • Desiccant cooling (if shown to be more viable than in the past)

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Energy Efficiency Performance Goals Sensors, Meters, Energy Management Systems			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Smart device – level controls responsive to user and environment	• Many stand-alone devices run uncontrolled with no occupant present (e.g., parking garage lights, motel PTAC, entertainment centers, etc.) Also deliver too much heating, lighting, etc. • Cost to add-on sensors is high (e.g., install an occupancy sensor for a light fixture) • Central EMS control is expensive and often not responsive to users • "Dumb" devices are not much fun. • Need low-cost control capabilities • Standardization of protocols • Sufficient intelligence somewhere in the system to manage conflicting inputs	• Occupancy sensor controls available in common devices (see gaps) (S) • Standards for electronic devices (S) • Extension of smart controls to lighting and HVAC (M) • Standard practice for all electrical devices that directly serve people includes smart control logic and sensors to modulate energy use to optimally correspond to user needs (L) • Modular generic control/sensor packages are available at low cost (10% of device cost or less) (L) • Modular generic control sensor package responding to occupancy temperature light level, air quality, and user input (L) • User input is standard, cheap, and ubiquitous (e.g., by cell phone, standard IR controller, voice command, or similar) (L)	• Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input
Easy/simple user interface controls	• Based on manufacturer design • Does not consider demographic operability • Make user experience as important to EMS manufacturers as it is to Intuit and Sony	• Survey consumer needs (S) • Support demonstration projects (M) • Create standards (L) • Interfaces need to allow for different levels of sophistication of users (L) • Controls need to connect to large number of devices/features to allow users to address amenity control needs (L) • Control management system should be implemented where appropriate, reflect user/occupant known preferences (L) • Need standardization of communication/control protocols to allow for variety of interface devices and approaches (phones, RFID cards, PCs, integrated amenity control devices, etc.) (L)	• Industry-wide user experience test standards and minimum performance requirements

Energy Efficiency Performance Goals Sensors, Meters, Energy Management Systems			
Energy Efficiency Product & Service Area	**Gaps/Needs**	**Performance Goals – Short (S), Medium (M), Long (L) Term**	**Gap-filling technologies**
Consumer Energy Management Services	Residential: • Homeowners do not have expertise to manage energy • Very small marginal savings available • Rates are changing and hard to understand • Homeowners need to control energy costs and be able to respond to higher rates and changing rate standards Commercial: • Lack of energy management expertise • Single sites have small marginal savings	• Bundle energy management services for cost effectiveness (S-M)	• Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input
Low-Cost Savings Verification Techniques	• Need to be able to attribute energy performance improvements and affects to actions/widgets to: - Value and measure impacts of our investments (utilities, states) - Provide consumers with information/feedback on energy affecting decisions • Devices for measuring widget performance are currently relatively expensive add-ons that are expensive to retrieve information from.	• Low-cost savings verification techniques (L)	• Savings verification monitoring, data collection and transmittal devices on a chip that costs pennies and can be incorporated into any product
Real-time Smart Electric Power Measurement of Facilities	• No standard technology • Retrofit is expensive • Devices lack intelligence • Results can be complicated • Consumer are not motivated	• All utility customers have networked smart meter in 8 years (S-M) • Create standards (M) • Numerous appliances and devices have embedded and networked power meters (M) • Legislate compliance (L) • All electric end-uses over 1 kW have embedded and networked power metering in 15 years (L)	• Data collection, analysis, and customer feedback systems to optimize whole-system energy performance

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Appendix A3:
Workshop 2 (Technologies and Gaps) (Jan. 20, 2010)

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Agenda

Northwest Energy Efficiency Technology Roadmap Workshop #2
—Technologies and Gaps—
January 20, 2010

Location: NW Power & Conservation Council, 851 SW Sixth Ave., Suite 1100, Portland, OR 97204-1348

Purpose of Workshop Series:

- To develop the framework for identifying, selecting, and prioritizing high-value, energy efficiency (EE) research, development, and commercialization to be pursued by Northwest organizations and agencies

Purpose of Workshop #2:

- Identify solutions for available products and services that are not more widely adopted due to technical barriers.
- Identify R&D program gaps and formulate programs to address them.

Wednesday, January 20, 2010

9:00 am Welcome and Introductions
- **Terry Oliver**, *Bonneville Power Administration*

9:30 am Background and Context
- **Joshua Binus**, *Bonneville Power Administration*

9:45 am Description of Workshop 2 Process and Goals
- **Tugrul Daim,** *Portland State University*

10:15 am Sub-Group Breakout into Product and Service Areas

Tasks:

1. Confirm/modify technological solutions which can be applied to enable currently unavailable products and services needed over the next 20 years.
2. Confirm/modify existing R&D programs which are addressing the technology gaps discovered in Question 2. Where are they?
3. Formulate new R&D gaps programs needed to address technology gaps.

Noon Working Lunch – Continue Sub-Group Breakout session

1:00 pm Report to Group / True-up Findings

3:45 pm Closing comments, Next Steps

4:00 pm Adjourn

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NORTHWEST ENERGY EFFICIENCY

TECHNOLOGY ROADMAPPING WORKSHOP # 2:

TECHNOLOGIES AND GAPS

MEETING MINUTES

JANUARY 20, 2010

List of Participants	
Name	**Organization**
Terry Oliver	BPA
Mark Brune	PAE Consulting Engineers
Nick O'Neil	Energy Trust of Oregon
Tom Reddoch	EPRI
Mary Smith	Snohomish PUD
Jack Zeiger	WSU
Ryan Fedie	BPA
Rob Penney	WSU
Jonathan Livingston	Livingston Energy Innovation
Pete Pengilly	Idaho Power
Bill Livingood	NREL
Dave Roberts	NREL
Mark Rehley	NEEA
Dan Colbert	UCSB
Jack Callahan	BPA
Reid Hart	PECI
Bill Koran	Quest
Rem Husted	Puget Sound Energy
Joshua Binus	BPA
Todd Currier	WSU
Fred Gordon	Energy Trust of Oregon
Graham Parker	PNNL

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Project Administration:

Project Manager: Joshua Binus, BPA
Consultant: Tugrul Daim, Portland State University
Ji Sun Kim, Portland State University

Workshop Facilitation: Jan Brinch, Energetics
Ndeye K. Fall, Energetics

Welcome & Roadmapping Overview

Joshua provided a re-cap of Workshop 1, and an overview of the purpose of this workshop on Energy Efficiency Technologies, as well as the schedule for completing the Roadmap. Terry Oliver spoke briefly to confirm the schedule and to add his thanks for all in attendance.

Reports of Breakout Groups / Findings

Group 1. Heating, Ventilation, and Air Conditioning

Existing Product and Service Domain: Low-carbon, sustainable, high-efficiency products and systems that automatically diagnose, predict, and maintain high efficiency throughout the product life cycle without sacrificing amenity or service delivery

GP5[1] – HVAC does not communicate two-way. Power Mand and Honeywell have many residential energy management systems. Not all intelligence has been incorporated in diagnostics. Research needs to be done here.

Communication issues. Internet visualization of thermostats; we need to put intelligence on diagnostics. Are people going to look at these screens?

GORDON: Retrofit variable airflow; drop in floor register; whole house forced air system; need to address leaking ducts, for homes. Gets back to thermal homes.

Improve COPs.

Expand and get more closed loop controls that integrate back into the system.

Water based systems to integrate geothermal into central unit; better efficiency.

Heat recovery, heat optimization routine; when you do heat recovery, system doesn't adapt well with the economizer. Haven't got system that does heat recovery and economizer; have to piece together, pressure drop issues. Need development.

Easy ECMs for residential furnaces; ECM motors; little documentation on savings; controls optimization. Current energy needs; reheat systems. An issue is there are no robust models that are easy to use, to drive systems, to compare systems and make intelligent systems. Move energy pull along, put more intelligence in; move into interval data, use model on on-going basis. There are R&D efforts.

HART: There are not enough models that are easily used to compare different systems. There is a whole piece about moving along and some idea tying this back to building interval data and displaying for people how the building uses energy.

[1] GP = Gaps

New GL4[2]: Damper Test needed. We don't have testing methods for dampers and they are needed.

TC1[3] – User-aware and self controls for the packaged HVAC unit and predict whole-system energy performance, rejected by the group.

New TC1 – Self-programmable smart thermostats
Self-programming thermostats that take care of themselves, provide notification and self-diagnostic information back to the user. Predictive energy use relates to this. Although there has been some work on higher-level systems, there is a need for small sized systems for HVAC. These programmable thermostats are missing the right software, so software development is key. BPA is currently funding an R&D project on economizer software; Sentinel and California Energy Commission/PIER are also doing some work on this. There is work going on with programmable thermostats.

TC2 – Predictive Maintenance
The issue is downscaling. You can get predictive maintenance, but it needs to be downscaled for packaged systems and needs an intelligent interface. BPA currently funding a study to redo the economizer and controls wholesale. There is not a lab test.

HART: That's another bullet. Manufacturers can be a part of the solution. Now let's look at economizing dampers.

TC3 – Economizers
Need to develop a load based lab test, instead of rooftop tests. Such a lab test would allow a series of loads and climates to be input, and then EERs developed and tested.

TC4 – Diagnostics for large-system ECM motors.
The technologies need to be applied to larger systems. It is a "belt drive" solution. There is a need for better mini-split controls that are on fast cycling between heating and cooling. We need both controls and commissioning because controls are not sophisticated enough.

GORDON: Is it a controls issue or both?

HART: It is a control issue. That's what will be presented at BESAC.

TC5 – Reliability of enthalpy controls
There are no tests to assure reliability. There have been some other tests and maybe they work better than we think. How do we know what is reliable?

Hybrid vapor compression has been researched through NBI and Colorado. The research is to reduce the maintenance issue. ETO and MBI have completed their research.

For self optimizing controls, why should you play with temperatures as smart as controller free and automatic transmission?

Indirect evaporate is not a system we see being developed. Hopefully a person in electronics addresses this technology.

Equipment rack that swaps a telephone room in a building so the chiller runs twenty-four hours a day, seven days a week has a separate heat recovery system.

GORDON: I see some level for room control. There is marketing for a product.

TC6 – Reduction in maintenance
There has been some testing, but research is needed to reduce maintenance. There has been some work done at the Energy Trust of Oregon; also, NBI has completed some research; but it needs some help.

TC7 – Self-optimizing controls
There is a need for small controllers that think as smart as controllers for automotive automatic transmissions.

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[2] GL = Goals
[3] TC = Technologies

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TC7A – Mechanical cooling added on to self-optimizing controls.

These controls need to be coupled with intelligent thermal massing to meet most thermal cooling load. Need to address the separate heat recovery systems in separate rooms that have been installed in buildings, and integrate them.

RD16[4] – Residential systems and field testing for the variable flows of individual rooms – Field energy testing and zoning scheduling.

Grocer waste heat recovery package system; get away from custom jobs. If it does make sense, needs to be modularized; not custom. All these heat recoveries are custom made, how can we go about modularizing that system?

RD18 – Water-based VRF Systems to incorporate geothermal with VRF – Geothermal heat systems present a cost barrier; the technology has to cost less and be more efficient. How it might be tied into building system; tie heat recovery into structural system. More information about energy use related to variable flow refrigerant systems; improving the controls. Also need to look at how they work and better mini-split control performance.

GORDON: Inverter driven control strategies.

HART: Lenox has had them for years.

REDDOCH: Lennox has a variable speed driven air system. It's a commercial product and a two speed is available.

GORDON: Nordai has something new out with inverter driven controls. Inverter driven heat pumps. There are no incentive programs for them.

CALLAHAN: Fred, are you thinking of ductless systems?

REDDOCH: We are testing the Daikin unit. It's the VRF version Daikin with thermal storage. Our field sites are being tested without thermal storage. Something is going on with the electrical side; fault conditions with motor associated with compressor stalls; bad impact on electric grid. What's going on and does EPRI report on that? Is it grid harmonics? It may tip the balance on some controls, use of inverters, or if you implement a variable voltage strategy, that's a problem. It all might have an impact. Right now there's a minor retrofit strategy associated with areas of heavy use. Standards needed? Place an asterisk on these.

CALLAHAN: It can be used for domestic hot water and heat.

OLIVER: Fault induced delay voltage recovery. The motor stalls and it has a very bad impact on the electric grid.

HART: Is that energy or grid harmonics? Need variable flow systems; what's good economics? Demand controls; demand control friendly.

OLIVER: It may tip the balance in some of the control systems.

OLIVER: ORNL has a couple of test houses. ORNL looking at residential market, test houses doing installed loop around base of foundation. There are research needs. Is anyone researching heat pump in heat recovery?

ROBERTS: Geo-exchange system with the largest HVAC – that's the refrigerant based.

REHLEY: We are looking at that with the heat pump water heaters.

GORDON: If there is a heat pump water heater, there is an application. Take heat recovery ventilation with the residential heat pump. It lowers heat loss of house and the heat recovery ventilation could be heat for a house. A project is planned in Colorado and the specs are getting squared away. The system is small enough to go with large HRV. Not sure where that stands. They may have abandoned geo-exchange, which was refrigerant based.

[4] RD = R&D Programs

FEDIE: How do we develop these technologies? How do we make them affordable, do we need R&D programs or do we need to better marry our industry with other industries? Is it better lining the utility industry with those players?

Really, what we need in these gaps is better technologies.

We do not need better insulation. We need to know how to move technologies to fill gaps. We have done a lot of pilots. How do we do smarter pilot? How do we better inform the builders and help them mitigate their risks? It is really about integrated building design. How do we make commercial building more modular, if you are changing HVAC systems? How do you mitigate the impact in the envelope?

BINUS: Are there any additional questions or follow up? Let's work on building performance next.

Group 2. Building Design/Envelope –New Construction

Overall Discussion

Lots of technologies currently exist. How can we make them affordable? Is there really a R&D need or to better marriage technologies with end users. Can we bring technologies to the market through utility programs? We need to pull costs out to get new technologies installed. What we need are better programs to get existing technologies deployed. We don't need better insulation, but need it better deployed using analysis and software tools. There are lots of pilots and we should be investigating how to do smarter pilots. How can we better inform builders; mitigate risks; improve knowledge of integrated science in buildings. For the Commercial sector, how to make buildings more modular and how to move cubes around and take better advantage of space.

Net zero energy homes

Let's take a look at technologies. For instance, non-conducting framing membranes an area to be concerned? Same goes for nonstick built homes. How do we codify and build net-zero homes in the future? How do we move toward more renewable buildings? What role do we play? There is a need for a micro heat exchanger, as we are trying to reduce on the HVAC side. Work is underway at the national labs.

How to install and integrate smarter plugs into the system by making plugs addressable and smarter. Getting renewables into the system. DC low power infrastructure. Need for micro heat exchanger that can handle low grade heat. Complimentary to the market. For R&D programs that are covering net zero there are few pushes happening out there in relation to the 2030 challenge. How do we get there?

Building labeling

Increasing labeling uniformity to address the market; increasing accessibility to data; and mapping out the regulatory/legislative incentives. Apply requirements for uniformity and initiate faster and cheaper ways to do things. Google camera, for IR scanning. What are other approaches to labeling? Labeling itself and how important it is to focus on and the role labels play to accomplish work.

GORDON: The Nation is still struggling with the conflict between simple and meaningful labeling. There is a conundrum between what the nation is defining useful and billable products. This is resulting in a lack of meaningfulness of home-ratings. What can it mean? Hallucinatory? What's useful and doable? Everyone knows what the market wants, simple cheap, accurate, readily transferable technologies.

Retro & New Construction Air Sealing

No additional discussion.

New construction insulation

No additional discussion.

Eliminating home penetrations

Let's take a look at surface mounted wiring and double wall systems. There could be something in here if we go to foam based framing. Finding a way of filling in when we do retrofitting that would not compromise the structure. Not a lot of R&D programs addressing this area.

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Day lighting walls
The greatest need is for easier and cheaper day lighting modeling tools that give you data. Deeper penetration of lighting to hit deeper into spaces. If a building is not designed right, how to put in shading fins for retrofitting.

Manufactured homes
In the NW, there is not a lot of adoption. Perhaps there should be a focus on modular designs in homes and automated or robotic assemblies.

IR scanning
We should think of a way for intersection of people doing things for leverage. Technologies trend to smart boxes – smart phones, etc. IR scanning of whole neighborhoods. IR camera to operate in partnership with smart phone to allow customers to scan their homes. We don't have to rely on utility cost structure to identify problems and solve problems. Let's get away from all energy decisions being made by utilities, especially if the savings are not big enough for utility involvement. View an application on a phone as an enabling technology.

GORDON: Energy trust; we are paying an IR air photo of South East Portland.

CURRIER: To get an IR camera built in a smart phone is for the end consumer so you are not relying on a utility program. We want to get away from having all energy decisions coming from utility. An IR build in a smart phone is an enabling technology that can help

FEDIE: The level of calls you are getting and the research on consumers.

REDDOCH: Can you rent an IR camera?

HUSTED: Consumers do not know that something is not problematic.

CURRIER: Right now, you cannot do that.

HUSTED: It could be a simple way to figure out the BTU/sq. ft.

Group 3. Building Design/Envelope for Retrofits

Overall Discussion
Enabling consumers to self-diagnose. Can you rent them? Consumers don't necessarily know of problems. A simple application identifies hot spots on walls by taking photos of kids. There is not a rental device in place. We could evolve applications into a whole labeling that determine or calculate heat loss. Many applications exist. We could figure more sophisticated information and it doesn't need to be so sophisticated.

Deep retrofits
Sparse in this area. Lots of technologies are out there; the gap is how to acquire them cost effectively. R&D needed for how to categorize building stock, identifying the technologies that we should be codifying. A deep retrofit goal is trying to reach 30-50% then 50% and after 50%, 70%. Probably can achieve first goal of 30-50%, then after achieving cost and packaging is the problem. Let's focus on different components and treat each as part of retrofit.

Similar to net zero conversation the bigger gap is going from 50-70% improvement.

CURRIER: The deep energy retrofit goal is trying to achieve 30% energy efficiency goals. The first goal can be achieved with the existing technology. It is not a technology problem. It is a cost problem.

FEDIE: There seems to be a bigger gap between achieving 50% and hitting 70%.

Labeling
CURRIER: We talked about energy modeling tools, some in the group were of the opinion, that simple smarter tools will be good and learning from the tools would be better. We need to learn from the modeling results and move on. Everyday designs,

so tools can be used by regular designers. Striking that balance is part of the challenge. Striking that balance is important; tools should not be just for experts. You should have tools that are accessible for regular designers.

KORAN: I have a somewhat different viewpoint. Things need to be simpler for some things or we run into issues. We need to move away from existing tools that do not model things very well like variable systems. If we go to simple for everything it may not have all the info. For example, all of us trying to talk the same language.

CURRIER: Simpler is about the front end, not the back end.

Retro and NC Windows

Some technologies are low-e, integrated with PV, and self powered. Electrochromic, next generation, triple glazed. These technologies are heavily insulated. The higher solar heat gain methods facilitate installation for orientation of glazing. What do we facilitate installation and glazing for the frames? How do we advance fiberglass frames? We have to improve glazing so we can then tackle the frames. For R&D of the current areas with Sage, Cardinal, and others are working in this area. Air sealing, there is enough field science to make it perspective.

GORDON: To put into perspective, let's take instrumentation out of the hands of contractors and advance the need for regional research on prescriptive testing. Contractors can follow instructions and install components. We want to limit contractors stumbling with installation so energy efficient window retrofitting and installation is easy and cheap.

FEDIE: Developing infiltration check lists that will supplement existing check lists for effectiveness.

HUSTED: We are doing something.

COLBERT: Buildings are fantastically complex systems. There are hundreds and thousands of parameters. One thing that several USCB groups are working on is understanding the most salient parameters. How do we identify parameters and make sense out of it so as to know what knobs to have. That's a big area of research at UCSB.

CURRIER: Residential upstairs and commercial downstairs. We need integration between needs of lower and upper floors.

KORAN: We see buildings being built with disregard.

CURRIER: Note this is popping up everywhere in urban areas.

HUSTED: There is a lot of cross over lighting and so on.

HART: We have performed these kinds of studies. We looked at small urban, district low level heat pump type. For instance, where you have a grocery store it might be cooler.

HUSTED: This will bring another problem from a utility.

HART: There is load heat sharing potential. There is some talk of looking at that.

O'NEIL: Did you touch on the fact that LBNL is doing some research in high efficiency windows?

CURRIER: In the windows area there are staged goals

PARKER: Did we talk about shading? We are not sure about the viability.

FEDIE: Not necessarily shading but shades themselves.

LIVINGSTON: Eleanor is looking into that.

REHLEY: On the day lighting, one technology that could use some work is the sensor. You have a lot of daylight.

GORDON: We covered it in lighting. We want a one or two step dimmer that is easily calibrated.

REHLEY: The big issue is usability.

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HART: There is technology that's easily controllable. It's an expensive technology that makes sense in productivity but is expensive energy wise.

Staged goals that fit into a middle goal. Net energy producers should be placed at the end of the time frame along with low-e coated window development.

Buildings, commercial and residential are very complex. By breaking space up into segments, air flow and other parameters; hundreds of thousands of them, air flows along better. SSS is working on (CA) predictive modeling tools for understanding most associated control systems. Diagnosing the most salient of those parameters you are not going to have knobs on all of those parameters. What makes the difference? How to pull knobs out? How do we know what to do? What tools can be developed to couple with control systems? LBNL, UC Berkeley, and other places are performing R&D.

Another thing Ryan mentioned is increasing amount of mixed use space. Take, for instance, a five story building under development. Then account the limited consideration that has been given to the different cycles for residential upstairs and commercial downstairs. Let's identify the ways to deal with that diversity and capture waste heat on the bottom to use above in residential units for the night. The need for R&D is to explore this.

Disagreement between different zones has to be addressed. There may be no stock strategy. First step is to determine how and where to get started. Shell measures, lighting, extensions, individual building studies, validation of mini-marts, nail shop, other things. Small urban districts with low level heat pump circulation systems. We can start to do something like that. For district heating, conduct heat transfer and load analysis. Potential needs to be addressed should include thermal sharing, zone heat transfer, metering, and utility perspective. There's been some study of this.

Current R&D programs are running for duct sealing. Tests and demonstrations need to be regional. The same goes for air sealing.

R10 & R12 glass systems available at LBNL. Are these technologies commercially available?

Transformative building materials

Technologies include phase change materials, in relation to mass, shifting loads. Insulating sheet rock alternatives; related to a self healing envelope.

FEDIE: Transformative building materials: face change materials, carrying mass, insulating sheet rock, products that may not have been classified as energy efficient.

HUSTED: Sheet rock does not have an energy saving component. There are many things that do not relate to energy but as someone is building a home the products that might not have been thought of previously as energy efficiency components can in fact save energy. For example, sheet rock if it is installed in a house, may be energy efficient. Different building materials don't have energy efficiency components but could allow for a better total home to be built.

Solar/smart roofing

Solar shingles. Water collection systems might tie into hot water heating. Finding good sites for solar by using modular hand held devices that are designed to find good solar sites for the residential sector. Green roofs don't offer enough savings. Could green roofs be coupled with solar systems and reduce heat on the roof? PSU is doing some research on this. Building prototypes. What would be the necessity if you can get better R value insulation? Value is in storm management. Energy portion of benefits is under 10%.

GORDON: Eco roofs do not seem to have come up. We have not found any.

FEDIE: PSU is.

BINUS: A big driver is storm water management and not energy efficiency.

GORDON: Our conclusion is to understand energy portion in relation to total benefits.

Retrofit insulation

A lot of this revolves around better wall insulation; something more easily deployable, less intrusive. Related to that, is there a better device or method to improve penetration? Related devices that also operate for IR scanning? A possible R&D program is for development of a smart material that is self healing and self expanding once inserted into cavities and spaces.

Effective insulated shades

We aren't really sure about shading viability; when we are talking about fenestration we are not talking about shading externally but shading for shading's sake. We are looking at balancing a need for privacy and day lighting controls. The truth is we can develop better shades. LBNL is continuing on that path with its development of automated blinds. On the issue of day lighting, a sensor on a controlled system could help in balancing ambient and day lighting. This is not reflective lighting that you want; it's the ambient and day lighting. Usability and controlling for glare. There is technology available that takes commissioning requirements away. This technology remembers what you like, preferences are recorded, although this is an expensive technology in terms of energy, but overall is a good value.

Group 4. Electronics and Lighting

Group 4a. Electronics

Sleep mode

LIVINGSTON: For electronics, let's realize that it covers a lot of ground. Therefore, there are gaps we didn't cover. For sleep modes, there are complete gaps.

We saw a lot more research ideas than technology ideas. We tried to focus on what we saw. Preset sleep modes where the sleep mode is programmed in. Take for example, late night network admin updates. The network administrator does not like the sleep modes. Best practice is to implement sleep modes that are already programmed in late night network updates.

R&D should focus on optimizing user interface and make it easier to put things to sleep. Understand how users affect behavior economics and investigate behavior economics issues and how people interact with technology. What the fault is of the technology. What the defaults are.

Do we need to power down after a certain amount of time? What people can and what do people want to do? User sensing controls. Research programs include Sharp electronics, Camus research, and watt stoppers. A lot of electronics companies are doing research on preference controls made easy for users. Sleep mode to other types. Optimize user interface and make it easier to put things to sleep.

Suggest opt in and opt out programs for driving people's behavior. It has a lot to do with what the defaults are and whether people want to and will use the systems. You can generalize a lot of these modes in a lot of types.

DC power source

Easy adapter for AC equipment to adapt to DC. Low cost, low loss, and standardized. In tandem wiring of buildings for AC and DC. Overall concept for AC/DC transformer; in OEM as part of the equipment. DC, beyond the air conditioner. Research DC safety. Prepare better guidelines for electricians and consumers. Reduce loss reduction as cost effectively as possible. Need for a power line carrier system for DC: it can be a cheaper and ubiquitous solution.

CURRIER: EPRI has conducted research on DC power for data centers. How much of the stuff in homes in native DC vs. AC? Does it make sense to power homes in DC and convert a few? Does it make sense to power DC and then convert to AC. What percentage is that – electronics 100% DC? That's the stated power.

REDDOCH: Speed and innovation with electronics, number of electronic devices moving so fast, how we supply those we aren't thinking. To transition mentally we have to catch up on the supply side. We require every device to do something with it. Our thoughts, traditional AC transformer has to go, becomes a DC device. Migrate that up the distribution system. We are with an AC system and there are so many electronic devices coming up that we have not gotten our head around. In actuality, the AC transformer can become a DC device that you can migrate.

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GORDON: There is competition in integrating the DC system. The competition lies between smartening up DC elements and collapsing the load rather than serving it. May not be an either, or strategy. Have to survey DC devices to understand where it's going.

Universal adapter for DC – we need to plug it all in. All DC connections the same; get to a DC bus. They're all different. We want a universal adapter with DC. UPS /PV integration seems like a no brainer.

REDDOCH: We have launched such a project. Our challenge-Duke Power.

COLBERT: EPRI has launched a project to get a data center to let them experiment powering as DC, not AC. If you want another, UCSB got a grant from Google to set up a data center.

ZEIGER: We installed a server room with 230 volts and it turns out to save more energy. This server room with 230 volts at a higher voltage with all equipment on the 230 volt switch experienced no equipment change. Saves more energy. DC power has energy saving benefits. We need to characterize a better research agenda.

COLBERT: The inverter losses are proportionally smaller.

LIVINGSTON: Read GP3 of the roadmap.

Use and virtualization

1. Potential research project, taking triple play and putting it on the internet.
2. Retinol projectors and direct connect to the optical nerve – ergonomic research.
3. Bigger is not necessarily better, 50 inch screens give way to 70 inch screens
4. Visual performance impact: we need research to talk about comfort and how effectively people can do their jobs.
5. Digital performance research: user comfort with virtual reality gloves to understand comfort and how effectively people can do their jobs. Back up user comfort with goggles.
6. How do we create software that takes all the info and how to create software that gets info overload and condenses it down creating a synopsis.
7. Improving information management and awareness of energy used. Research at LBNL on data network.
8. Internet energy usage.

COLBERT: The army is doing retinol.

Component level efficiency

COLBET: It is for transmission and information transmission. Photons do that much faster than electrons. It will never be 100% optical. The next USB cable will have an optical interconnect USB 3.0 will look the same.

LIVINGSTON: R&D to be conducted for integrated solutions, power supplies,

Integrated solutions for device components. Broad research on component opportunities chip sets, display devices and looking across an entire range to see where R&D should be done. Some thoughts are power supply efficiency and chip efficiency where many subsystems to be optimized, could also include plugs. Better CCC.

Complete electronic systems

For complete systems we would like to see a 50% energy use reduction set as a 10 year goal. 20 year goal to be added considering a 90% reduction in energy consumption. Software is actually driving system to be more efficient. Talking about windows of the future. Super efficient heating and cooling and servers. Finding uses for the best available technologies. For example, a 40 inch screen that uses 10 watts.
CURRIER: Super efficient PV. The idea is to develop a product that uses the best technology and uses research funds to illustrate what the best practices look like, integrated with algorithms and device architectures.

COLBERT: I want to add one word on integration. Integration is huge such as integrating building design with all the cooling and heating. Up to now, these have all been separate endeavors.
Integration is a real watchword concerning research, computers, data centers, the integration of cooling and control systems, and algorithms. There is a huge scope for integrative design solutions and applies across the board. We need lots of research on ergonomics, to show to people that they can be happier with less.

GORDON: We need to make people understand why they like what they like.

OLIVER: With the possible exception of dwellings, I have not seen studies that say that because fridges got bigger, fridges got better. No studies show that increasing size outweighs the benefits of increased efficiency. Bigger is not necessarily better. The existence of technologies that reduce energy consumption have some technologies far less susceptible to that. What is the user value from energy efficiency research?

Interlock devices to manage energy use

GORDON: Where can we make things more integrated to do x, y, z? Interlock devices to manage energy use – automated systems, hotel key. More research is needed to take us beyond hotels and into homes, zero net energy homes, smart houses and lead the next generation at least from a behavioral research viewpoint.

Have we investigated in trying standby losses? Smart strips? Should these technologies be built into the various devices? Let's require standards for various devices and tie into TC 1 an access to the chip. Investigate why people aren't following them. Software architecture is another area where more work is needed.

HUSTED: Was there discussion of automobiles?

CALLAHAN: Automobiles – didn't touch on them. As for power differences, manufacturers won't care. How about network computer management controls – is there a technology? Or a sleep mode specifically for managing networks of computers? Look at network management software.

LIVINGSTON: We talked about the fact that there are obstacles to adoption. May

CALLAHAN: I wish I had Charlie Grist here to talk about it.

Group 4b. Lighting

Lighting

LIVINGSTON: The good news about lighting is that we are all pretty familiar with it. We debated about the fact that this is non-solid state lighting. We looked at Plasma lighting and the luminaire design and optics. This captures what's not captured in other areas. Look at red LED and compact fluorescent, poor color rendering. Lighting productivity research. Self cleaning fenestration products – can it be applied to luminaires and reflectors? We know that California Lighting Technologies Center, LBNL work in day lighting and the CEC/pier prominent lighting efforts should be looked at.

TC2 – Add the missing red component by using an LED. We think CFL might be a bridge technology that needs to be replaced.

Solid State Lighting (SSL)

Designs for the many different applications that use lighting well, tiny induction lights
Solid state – not just about LEDs, and others. Plasma and others. Day lighting, and SSL – should be another category. Solid state and designs for many different applications. Re-think lighting. Highly inducted lighting. Electric system compatibility. Radio frequency interference needs to be worked out. Lighting doesn't interfere with other products.

Understanding failures and heat dissipation of LEDs. A hot technology, but if you can go to 2200-3000 lumens per watt, you can get heat emission down through processes of centralizing and getting heat recovery off of it. Get LED generated heat down to the foot waters.

Improve task/ambient application

Better fixture design. Put light where it's needed, not everywhere. This leads to a big problem over time. Don't light entire space and their desk. Place light where needed. LED is becoming more inexpensive so let's come up with smart controls. Avoid the effects of walls, for example unattractive hospital lighting. Lighting in hospitals is a great example of lighting that is overdone. Well lit spaces could make sense but also don't. Huge HVAC loads. Why is task management/ambient not taking off? Build task lighting in cubicles that are LED based. Design standards, IES standards. Lighting designers won't design 15-20 foot candles at the desk top. Implement incentives to promote this.

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Human tasks - Should take human factors into account through finite designs, research programs, and PIER program.

Lighting controls (dimming, OC sensors)
Better location of occupancy sensors. Settings that are easy to understand. Anyone can set them off and set settings down. Develop simpler and self calibrating controls. Use a computer to adjust the entire system.

Predictive modeling conducted Research at the California Lighting Tech Center.

More efficient luminaires
CFL ballasts that don't experience potential life. Higher lumen per watt. Further enhancements that can be run out of these. Perform human factor research. Lumanaires research should be re-opened, to understand the human factor new sources. New IES metrics. Legitimized outdoor lighting and bluer light. Understanding luminaire design will lead to understanding gaps.

Adjusted GP 1 under day lighting. Cheaper simpler day lighting controls. Glare research and work; see the names of the organizations doing some of this work.

Day lighting
Advanced software for simulation for better coordinated lighting design and sensors placements. There could be tools developed to make sensors easier to use on the front end. This is a very complex field. We need to find ways for the user that could be easier for them.

Group 5. Sensors, Meters, Energy Management Systems (EMS)

Smart device level controls
CALLHAN: Standards are important to enable smart device level controls. This is a technology and a research area. Another thing is to eliminate sensors so you can get the data otherwise. This is tied to direct use controls. Not aggregating end uses. This is dis-aggregated devices. They overlap. This is an outside the box idea.

Easy/simple user interface controls
No additional discussion.

Consumer energy management services
SMITH: I am less familiar with the Google. Utilities Microsoft Home is more like Aclara. They simulate the house and partner with vendors. They tie your home by zip code to sell you services.

TC1 – In the near term occupancy sensors will need to be cheap, standardized, user-aware, and able to respond to occupancy temperature, light level, air quality and user input. As LEDs start penetrating, fixtures address occupancy. On smart phones, cameras, different devices, infra red control; control a fixture. Re-purpose existing technologies while integrating with other control systems. Communications standards are important. Wi-Fi and zibee are not ubiquitous standards.

GORDON: It is an industrial level.

HART: It is oriented also at commercial facilities. PGE is marketing small commercial technologies – internet tools more oriented at commercial users, plugs into interval data, and normalizes energy use for current period vs. past use –to their customers at very reasonable rates. A number of utilities are changing their billing systems. SAP is taking a number of users off their projects. You'll have a lot more info on end uses. Eliminate sensors where you can collect data externally.

We noted that some of the stimulus money will help. The emphasis is on job creation, home and small commercial audits-marketing tools to get consumers to invest in retrofits. R&D programs such as scanning. Cell technology for transfer. Research as to what degree these are autonomous agents? If you have all these individual devices, how do they fit into the systems? The goal is finding integrated electronic systems to help you manage.

Best Buy's vision is that the geek squad will look at your computer and do an energy audit
In 10 years, they will do the retrofit wiring so you can plug in your car.

LIVINGSTON: There are companies that go out and install sub meters and provide user names and passwords. Commercial customers log onto web sites that sell tools to analyze that data.

SMITH: We talked about the Avista product.

GORDON: I think the big gap is how all this info leads to action. We do not have the best practice yet. Right now it is data mining and mailing people stuff.

SMITH: We have a lot of data and we do not know how to use it very well. How do you translate data into action items? How do you translate it into something useful when there is a lacking relationship among customer needs? There is lots of data that we don't know how to use very well. And there are pieces of data that just don't correlate. How do we translate data into actionable items? Thinking about coordinated apple i-phone applications with everything integrated. We need to understand consumer needs for convenience and control.

GORDON: What does the consumer want to use?

SMITH: Best Buy approached the problem in a different way; they think the question is what the computer wants. They want all the remote controls integrated. Best Buy is piloting with Apple on a device that will open your garage door, set the temperature in your home and so on.

LIVINGOOD: Let's make use of the sensors already there or add sensors. Devices developed for specific purposes, not integrated across all data. Doesn't understand what's going on with energy use. There are sensors in industrial processes; how do we get that in residential commercial environments. Get around issues with handling many pieces of equipment that don't use very much – triage approach. Contractors with energy expert skills understand opportunities through contractors by other means.

Low-cost savings verification techniques

No additional discussion.

Real-time smart electric power measurement of facilities

No additional discussion.

Enterprise energy and maintenance management systems

Enterprise energy management systems' gap on gathering information is what information we should be getting – how does it get obtained coincident in time. Need to analyze the particular data and then to communicate the info. Security fire walls – organizations don't want to deal with it. Reluctance to deal with it. Research underway to deal with this. Nebraska PKI on gathering of data. Make use of sensors already existing in roof top units and diagnose every failure mode. Gap – processing synthesizing the data. Northright, for example, is partnering with energy service companies.

KORAN: Getting around some of the issues we see in trying to handle sensors. They are partnering with contractors and knowing where they have specific needs using this ad an additional service to the customer.

GORDON: Did you discuss the fact that some companies like Air Advice are doing temporary metering. We are curious about building savings.

LIVINGOOD: Energy management systems do not accomplish their extent due to lack of expertise on the ground. If you do a central model and the example is like Wal-Mart, they have operations centers with experts that make sure that EMS are functioning properly. If you went to a more central structure, a more possible structure could assure proper installation. Monitoring of EMS systems needs to operate and the building needs to operate as expected. Compare lighting with store hours and with other things to control contractors and expertise at local levels, need to organize and consolidate information

GORDON: They are also smart enough to make control vendors make their products work.

OLIVER: There was a lot of movement at Grid Interop. You have a lot of messaging overhead in the internet protocol and they want to condense the headers. Movement reported out of Grid Interop conference in Denver – allowing communications down to zillions of devices. The vast majority of Internet providers are stuck on IP-V4 and the barrier is that they need to move to

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IPV6.   Private networks, small devices. Work group to condense that down. Have to get to IP version 6 to handle information management.

SMITH: Develop algorithms and protocols for security. Residential small commercial space and communications needs. Not a uniform consistent system for gathering electrical data and having it smoothly flow from sensor all the way up. Added gaps for consumer interests, security and convenience. Occupant desires personal control. Key theme, focusing not on energy alone.

LIVINGOOD: The algorithm was making the transformation of raw data into useful insights.

CALLAHAN: Let me go back to Product/service area called smart device level control. For this to work it needs to roll up from sensors to useable actionable information that someone can work on. To get that smooth flow from the sensor level all the way up. The gaps are saying that devices are running very poorly control. That's a weak driver.

GORDON: There are a lot of businesses. One was energy hub and that thermostat is just a relay, now maybe we can make an I-phone application. All the manufacturers have ideas but they have no data on easy/simple user interface controls. One technology – sensors. What data do consumers and researchers actually use? As important is the data nee so is its use to include behavioral information.

PENGILLY: We have talked about that all day and about what customers want. We need some research and surveys about customer behavior instead of stating opinions based on our intuitions. I think people will like the I-phone but that's just from my perspective.

HUSTED: Our own perspective – more research is needed via focus groups, and other things like that to research customer behaviors and figure out what they want. One IEEE paper said 56% of our changes will come from behavioral changes and 44% will come from gadgets.

CALLAHAN: He presented the last P&S of page 2 of Sensors and EMS. He then presented the second P&S of page 2.

KORAN: There are tools that do that on a monthly data. There are no tools that do that on a more granular level. It is done by engineering firms but they are not using statistical data.

KORAN: Universal translator tool is to help facilitate analysis of data. One of these issues is always to say how much data is enough. ASHRAE is looking at how much data is enough to create a statistically robust model.

KORAN: We discussed the impact of changing things that are not widget? If you change a temperature set point, it is changed at a fan. Utilities want changes by measure. When you try to measure those savings, you cannot do it on that basis. This is a change in paradigm.
FEDIE: Maybe this is about key performance indicators.

CURRIER: We need to think about the total effect.

PENGILLY: This will depend on our regulators.

SMITH: I think the regulators struggle with how to assign savings to the costs.

KORAN: We need to aggregate the costs and savings.

SMITH: The feedback goes into the call center at the utility. We always get the call.
LIVINGOOD: Per the functional need that you serve, there is a EUI and if you are above the baseline, you are responsible.

GORDON: You are getting into the curse of EMS.

GORDON: Start with interval data and say where can we find commonality. Everyone will have interval data on large and medium buildings.

KORAN: There is a draft out called Performance Measurement Protocols that addresses commercial measurement protocols for subsystem metrics.

Closing Remarks

BINUS: Can we conclude?

REHLEY: We asked everyone to conclude by discussing what they liked, what you would change.

OLIVER: I really enjoyed it. It is starting to gel. Hard to do, but good information. Everyone has a role to play. Looking forward to the homework we are all doing to drill down – what else is going on.

BRUNE: Link studies with emerging things. Don't duplicate. Only do different. Break down into smaller subsets. Include less information in smaller increments.

O'NEIL: I found it very useful. To make it different next time, let's break it down into smaller topics.

REDDOCH: What was different in this session, the team was different from session. It was helpful using what we collected from the first meeting and layering it out with additional discussion. We collected a lot of fresh information.

SMITH: The structure was good. The thing that hit me today is that there is a lot of richness and we should do this on an ongoing basis. I don't know what frequency to host but certainly not every 3 years. We need a series of meetings to keep information at our disposal around the region.

ZEIGER: I thought our results are pretty impressive. It would be good to do this again.

FEDIE: I really like seeing all the additional info we added. I am excited to see one big roadmap. I wonder if there is a way to get this through tech advisory group - TAG. We need to have more breaks.

CALLAHAN: The technical advisory groups were purposed to meet often.

PENNEY: This was a team of talent. I look forward to seeing how this will be implemented. I like the potential for more networks outside of the region. If we can link together more we can accelerate our success.

LIVINGSTON: I found this really enjoyable. Nobody seemed to be here with their arms twisted. We were fortunate in the lighting group to have a veteran of the first workshop.

REDDOCH: Do not let the previous group confine your thinking.

LIVINGSTON: We were not confined.

LIVINGOOD: It is really nice to think and it is interesting to have such diversity in this workshop.

SMITH: We need to get this information to other utilities because we are all tied up.

LIVINGOOD: I really enjoyed this.

ROBERTS: It would be nice to get all this information in writing.

REHLEY: It was interesting to me to see the level of details we drilled into.

CALLAHAN: I agree with everything that has been said. Each new layer adds more value. Maybe we need a smaller scope for the breakout group

OLIVER: If you want to expand this, maybe we need to do it one afternoon at an IEEE Meeting.

NAME UNKNOWN: I learned a lot. One comment is that I felt like I dropped in. I want to see an ongoing product of some kind. Access to the transcripts would be wonderful.

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KORAN: It was really great to be here because of the breadth of knowledge we shared. I look forward to seeing the final products.

HUSTED: This became a lot more focused. I can see a lot more actionable items coming out this round. We missed a lot the first go around.

BRINCH: Our job is to get all the information out so it is accurate and so it tells a story. It is a huge step forward in the technology of EE if the information can be appropriate to IEEE and ACEE audiences and so that others can learn from you.

CURRIER: I will pass on echoing comments. I will point out one thing. Where do we talk about buildings as a system? We focused on disintegration.

GORDON: Great group, great execution.

BINUS: It sounds like we had a pretty productive day. The task now is to get all of this transcribed. We cannot get it out for comments before the next meeting on Feb 5. We need to boil it down by March 1 for Terry O. Managing your expectations on what the roadmap is. As far as ongoing work, the next challenge is how do we refresh the roadmap?

SMITH: This is not only about refreshing the roadmap but also how to also integrate some of the contributions so the region can contribute to this dialogue.

Workshop Adjourned

Product/Service Area: BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO) 1/2

Deep Retrofits for Residential & Commercial

GAP (GP)
- GP1. Awareness / training / technology
- GP2. Easier methods to determine needs, financing, product development, codes and enforcement certification and branding
- GP3. Non-utility weatherization funding

GOAL (GL)
- GL1. 5% of market 30% savings (ST)
- GL2. 10% of market 30% savings (MT)
- GL3. 50% less energy consumption (LT)

Technology (TC)
- TC1. Self-programmable Smart Thermostats
- TC2. Technology exists, need to apply it at an acceptable cost for homeowners
- TC3. District heat planning, sharing
- TC4. Mixed use: use heat from commercial for residential, integrate markets
- TC5. Existing building commissioning tools
  - Building screening tools
  - Energy savings and estimates (CA Pier Project)
- TC6. Controls, demand response on
- TC7. Building control schedule/strategy

R&D Program (RD)
- RD1. Categorize building stock for better, easier testing
- RD2. R&D for TC4.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Labeling

GAP (GP)
- GP1. Determine what it is
- GP2. Get stakeholders to adopt
- GP3. Develop national/regional stakeholder
- GP4. Strong branding

GOAL (GL)
- GL1. Consensus on labels (ST)
- GL2. 20% of homes meet standard (MT)
- GL3. Mandatory (LT)

Technology (TC)
- TC1. Energy benchmarking tools
- TC2. Data aggregation systems
- TC3. Labeling
- TC4. Applications that make testing easier to do

R&D Program (RD)
- RD1. Test – new tools for modeling that are attempting new approaches to computer applications @ LBNL, DOE

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Retro and NC Windows

GAP (GP)
- GP1. Lower cost & better technology
- GP2. Design – education training
- GP3. Code national/regional (day lighting) specs
- GP4. Shift industry focus from residential to commercial performance standards
- GP5. Better labeling
- GP6. Concepts for next generation "same R-value as a wall" or ZNE windows
- GP7. Electrochromic issues such as cost, life, performance
- GP8. Address seamless PV integration into fenestration

GOAL (GL)
- GL1. Increase window codes residential and commercial (ST)
- GL3. Residential envelope performance standards (MT)
- GL4. Net energy producing 50% market Skylights become alternative for lighting (LT)
- GL2. Switchable window/PV 5% of replacement market (ST)

Technology (TC)
- TC1. Next-gen coatings for triple-glazed IGs with superior SHGC and U-factor ratings
- TC2. Integral low-E and PV windows
- TC3. Self-powered electrochromic-PV windows
- TC4. Glazing, vacuum filled 1-pane, low-e windows
- TC5. SH6 with low-e windows
- TC6. Fiberglass frames
- TC7. Heavily insulated electrochromic windows
- TC8. Methods to facilitate orientation specific glazing

R&D Program (RD)
- RD1. What is there beyond fiberglass – highly insulated, lightweight
- Look into R&D @ companies such as Sage and Cardinal
- RD2. R&D for TC1.
- RD3. R&D for TC2.
- RD4. R&D for TC3.
- RD5. R&D for TC4.
- RD6. R&D for TC7.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

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Product/Service Area: BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO) 2/2

Transformative Building Materials

GAP (GP)
- GP1. Prefab components for low-cost ZNE construction
- GP2. Make it easy for inexperienced workers to build right
- GP3. Reduce carbon footprint of typical materials

GOAL (GL)

Technology (TC)
- TC1. Modular, pre-insulated wall, floor, and ceiling units
- TC2. Self heating insulation
- TC3. PCM wall board, etc., phase change material
- TC4. Products that may or may not have EE components but improve building designs and improve techniques that can save energy
- TC5. Insulating sheetrock alternative
- TC6. Insulated building exterior material
- TC7. Transitive building envelope designs, load shape

R&D Program (RD)
- RD1. R&D for TC5.
- RD2. R&D for TC6.

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Solar / Smart Roofing

GAP (GP)
- GP1. Technology / price / standards
- GP2. Distribution / adoption
- GP3. Local restrictions
- GP4. Data / easy to install

GOAL (GL)
- GL1. Products readily available in marketplace at a low cost (ST)
- GL2. Intelligent buildings with PV (MT)
- GL3. Buildings codes that required solar (LT)

Technology (TC)
- TC1. Modular PV installation systems, including electronics
- TC2. Cool / PV / DHW heater roofing
- TC3. Solar survey mobile application for residential (exists for commercial)
- TC4. Water collection systems
- TC5. Solar shingles

R&D Program (RD)
- RD1. R&D for TC2.
- RD2. R&D for TC3.
- RD3. R&D for TC5.

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Retrofit Insulation

GAP (GP)
- GP1. Training / methods and technologies
- GP2. Awareness – identification of need at a low cost, easier to install

GOAL (GL)

Technology (TC)
- TC1. Insulation optimization via IR scanning & analysis software
- TC2. Community aerial IR scan + GPS data systems
- TC3. Neighborhood scale approaches
- TC4. New materials, cheaper and easier to install
- TC5. Device or method to better insulate walls
- TC6. Device that scans IR and calculates heat load

R&D Program (RD)
- RD1. "Smart" material that fills all cavities, mistake-free and inexpensive
- RD2. R&D for TC2.
- RD3. R&D for TC6.

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Effective Insulated Shades

GAP (GP)
- GP1. Better product/awareness
- GP2. Aesthetically appealing

GOAL (GL)

Technology (TC)
- See windows
- TC1. New materials for thin, super-insulating fabrics
- TC2. Window-integrated insulating shades
- TC3.PV-integrated window shades

R&D Program (RD)

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Product/Service Area: Building Design/Envelope for New Construction (NC) 1/2

Net Zero Energy Home

GAP (GP)
- GP1. Effective design
- GP2. New technology
- GP3. Education and training
- GP4. Code change
- GP5. Encouraging high density
- GP6. Architect and engineers, installers, code/manufacturing
- GP7. Branding urban areas and certification / commissioning

GOAL (GL)
- GL1. 5% - 50% better than code (ST)
- GL2. 20% - 50% or better of that 50% are net zero after that code (MT)
- GL3. All new construction zero energy by 2030 (LT)
- GL3. Building America – risk lies going from 50% to 70%

Technology (TC)
- TC2. Low power, DC wired homes – reduce conversion losses, buildings built for no respect to dissimilar loads and zones and no stock assessment
- TC3. Non-conductive framing members
- TC4. Non-stick built homes
- TC5. R10 structural sheeting
- TC6.Smarter electrical plugs, programmable, addressable (in development)
- TC7. Micro heat exchangers that can handle low temp waste heat
- TC8. Renewable building materials
- TC1. Design & analysis tools to integrate components and predict whole-system energy performance

R&D Program (RD)
- RD1. Predictive modeling to determine what knobs to have and control – work at USCB, LBNL
- RD2. Existing – 2030 Challenge, DOE, PNNL, NREL, ORNL, LBNL
- RD3. R&D for TC2.
- RD4. R&D for TC6.

Legend:
- TC – Technology Gap (R&D need)
- RD – R&D Gap (No known R&D)
- RD – Current R&D (R&D underway)
- Comment

Labeling

GAP (GP)
- GP1. Determine what it is
- GP2. Get stakeholders to adopt
- GP3. Develop national/regional stakeholder
- GP4. Standards for labeling

GOAL (GL)
- GL1. have labels (ST)
- GL2. 20% are using labels (ST)
- GL3. labeling mandatory increasing to meet zero energy (MT)
- GL4. Net zero label (LT)

Technology (TC)
- TC3. Faster/cheaper approaches
- TC5. Valuation of label
- TC4. Uniform MLS Requirement
- TC6. Access to utility billing data
- TC1. Energy benchmarking tools
- TC2. Data aggregation systems

R&D Program (RD)
- RD1. (Exists) Cal Arch, Energy I2 Action, Ecotype tool
- RD2. Energy information systems – numerous existing (see LBNL reports)

Legend:
- TC – Technology Gap (R&D need)
- RD – R&D Gap (No known R&D)
- RD – Current R&D (R&D underway)
- Comment

Retro & NC Air Sealing

GAP (GP)
- GP1. Data better/methods
- GP2. Training improvements in identifying

GOAL (GL)

Technology (TC)
- TC2. Checklists (test effectiveness)
- TC1. Next-gen substitute for blower door testing – cheap & easy

R&D Program (RD)
- RD1. Research to move air sealing to prescriptive and into hands of QC and out of contractors
- RD2. Application technology that is easy and cheap, even a caveman can do it

Legend:
- TC – Technology Gap (R&D need)
- RD – R&D Gap (No known R&D)
- RD – Current R&D (R&D underway)
- Comment

New Construction Insulation

GAP (GP)
- GP1. Better modeling / technology
- GP2. Modular homes
- GP3. Better materials with higher EE value
- GP4. Easier to ins

GOAL (GL)

Technology (TC)
- TC2. Foam/siding attachment
- TC3. Insulating structural panels
- TC1. Insulation optimization via IR scanning & analysis software

R&D Program (RD)
- RD1. Application technology, "easy and cheap"

Legend:
- TC – Technology Gap (R&D need)
- RD – R&D Gap (No known R&D)
- RD – Current R&D (R&D underway)
- Comment

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Product/Service Area: Building Design/Envelope for New Construction (NC) 2/2

Eliminating Home Penetrations

Category	Items
GAP (GP)	GP1. Better designs; GP2. Codes/products/technology; GP3. Training
GOAL (GL)	
Technology (TC)	TC2. Surface mount electrical; TC4. Products unrelated to energy savings but eliminate wall penetrations; TC3. Double wall systems; TC5. With foam based framing, how do you remove or add material for wiring, plumbing, etc. and how do you wire it; TC1. Modular, pre-insulated wall, floor, and ceiling units
R&D Program (RD)	Most technologies are already exist.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Day Lighting Walls

Category	Items
GAP (GP)	GP1. Measurable
GOAL (GL)	GL1. Design cost/complexity; GL2. Better design support tools
Technology (TC)	TC1. Easier, cheaper daylight modeling tools that give energy benefits; TC2. Devices for deeper penetration of light into spaces, i.e.: light shelf; TC3. Retrofitable exterior window shades
R&D Program (RD)	RD1. Devices for deeper penetration into space @ UBC, LBNL; RD2. R&D for TC1.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Manufactured

Category	Items
GAP (GP)	GP1. Follow codes/code improvement; GP2. Retro structurally engineered; GP3. Panels that can easily installed – spray on; GP4. Elimination of duct work
GOAL (GL)	
Technology (TC)	TC2. Automated/robotic assembly; TC1. Modular, pre-insulated wall, floor, and ceiling units Modular, pre-insulated wall, floor, and ceiling units
R&D Program (RD)	RD1.Shop floor innovative technologies similar to auto industry

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

IR Scanning

Category	Items
GAP (GP)	GP1. Lower cost/more awareness; GP2. Identifying need at a lower cost – part of labeling; GP3. Similar to car facts
GOAL (GL)	GL1. Cheap products widely available realtors/ contractors (ST); GL2. Thermal overlay major meter areas (MT)
Technology (TC)	TC3. IR Smart phone; TC5. Aerial photos to target; TC4. Google street view w/ IR; TC1. Insulation optimization via IR scanning & analysis software; TC2. Community aerial IR scan + GPS data systems
R&D Program (RD)	RD1.Marry the energy technology with smart phone/device technology

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Product/Service Area: LIGHTING 1/2

Lighting

GAP (GP)
- GP1. Optimized design of lamp, ballast / driver, luminaire, controls for ease of installation, operation, maintenance
- GP2. Optimize use of fluorescent, SSL, halogen IR technologies by application

GOAL (GL)
- GL1. 80% reduction in avg. lighting electric use in new buildings (through combination of more efficient light sources, more efficient luminaires, better controls, better application, and more use of natural light (LT)

Technology (TC)
- TC1. Hybrid fluorescent / SSL technologies for optimum performance, cost & aesthetics
- TC2. Luminaire optics for plasma light
- TC3. Red LED integrated into FCL for improved CRI

R&D Program (RD)
- RD1. Lighting productivity research @ LRC, Heschong Mahone
- RD2. Study health impacts of lighting @ LRC, others
- RD3.Self-cleaning luminaries
- RD4. Red LED integrated into CFL for improved CRI
- RD5. R&D for TC2.

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

SSL

GAP (GP)
- GP1. Reduce cost
- GP2. Increase efficiency
- GP3. Improve stability over time
- GP4. Better CRI
- GP5. Better understanding by lighting professionals
- GP6. Improve lumen maintenance

GOAL (GL)
- GL1. Demonstrations
- GL2. Training/education
- GL3. Target early, cost-effective applications
- GL4. 200 lm/W for 3500 CCT (50% of 80% goal) (LT)

Technology (TC)
- TC1. Super-SSL – next generation L-prize winner meeting all needs identified in Gaps column
- TC2. Manufacturing methods
- TC3. Fixture design for many different applications that use
- TC4. Tiny lights

R&D Program (RD)
- RD1.Electric system compatibility
- RD2.Substrate growth improvements @ DOE contractors
- RD3.SSL life extension @ Philips, Cree, etc.
- RD4.SSL heat dissipation @ Philips, Cree, NSC, etc.
- RD5. Improved light extraction @ Philips, Cree, etc.
- RD6. Can it focus better? @ Philips, Cree, etc.
- RD7. Better fixture design @ many luminaire mfgs.
- RD8. Thermoelectronic heat recovery from LEDs

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Improve Task/ Ambient Application

GAP (GP)
- GP1. Better user control of task lighting, including user-moveable luminaires
- GP2. Ability to have task lighting quantifiable reduce overall light levels and lighting energy consumption

GOAL (GL)
- GL1. Codes
- GL2. Training/education
- GL3. (15% of 80% goals) Establish as standard practice: reduced ambient light levels coupled with increased use of task lighting (LT)

Technology (TC)
- TC1. User-aware controls that reduce ambient levels for task and energy optimization
- TC3. Avoid "cave effect"
- TC2. Fine light for office lighting and classrooms integra

R&D Program (RD)
- RD1. Human factor- usability and comfort
- RD2. Hospital lighting systems
- RD3. Design standards @ IES
- RD4. Lighting systems for school, office, etc. @ Finelight / PIER

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

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Product/Service Area: LIGHTING 2/2

Lighting Controls (Dimming, OC Sensors)

GAP (GP)
- GP1. Cheaper controls
- GP2. More reliable controls
- GP3. Training and education
- GP4. Better human interface

GOAL (GL)
- GL1. 50% reduction (25% of 80% goal) (LT)

Technology (TC)
- TC1. Improved sensing technology to make controls more natural for users (poss. military-derived)
- TC1. Sensors don't light empty spaces
- TC2. Link to HVAC and Plug Load Controls
- TC3. Adjust lighting levels to time of day
- TC4. Better location of occupancy of sensors
- TC5. Easy to change setting on sensors
- TC6. Sensors that do not turn off when occupied
- TC7. Cheaper, more simple self calibration
- TC8. Building-wide user fixtures

R&D Program (RD)
- RD1. Predictive modeling for dynamic lighting needs
- RD2. Dynamic control of occupancy-based lighting Wattstopper, Lithonia?
- RD3. R&D for TC7.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

More Efficient Luminaries

GAP (GP)
- GP1. Market needs to be rewarded for efficient luminaries
- GP2. Change common metrics from source efficacy to luminaire efficacy
- GP3. Use FTE for outdoor lighting

GOAL (GL)
- GL1. In residential sector, begin shifting emphasis from efficient sources, to efficient luminaires

Technology (TC)
- TC1. Metrics for light delivered, task and aesthetic performance, not light emitted
- TC2. Ballast for CFL with low on/off penalty
- TC3. Higher lumen watt stick forecast

R&D Program (RD)
- RD1. Human factors – research on parameter for optimizing ? @ LRC
- RD2. Legitimize mesopic lighting @ LRC
- RD3. Change IES metrics @ IES
- RD4. Review and audit of various luminaire designs for various lighting applications. (?)

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Day Lighting

GAP (GP)
- GP1. More responsive controls, esp. for horizontal day lighting
- GP2. Easier to design, commission and operate
- GP3. Better light quality as perceived by users

GOAL (GL)

Technology (TC)
- TC1. Next gen ambient and task lighting sensors and controls
- TC2. Cheaper and more simple self calibrating dimming controls
- TC3. Core day lighting system
- TC4. Skylight design
- TC5. Day lighting sensors

R&D Program (RD)
- RD1. LRC increase (?)
- RD2. Research human and technology barriers @ LRC
- RD3. Core Lighting project @ UBC & CLTC
- RD4. Optimize day lighting with PC use @ LRC (?)
- RD5. Software for day light design – sensor placement @ CEC PIER
- RD6. R&D for TC2.
- RD7. R&D for TC4.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Product/Service Area: ELECTRONICS 1/2

Sleep Mode

GAP (GP)
- GP1. Retain intelligence
- GP2. Capability to restore to full functionality
- GP3. Responsive to user needs and preferences
- GP4. Minimal user interaction required

GOAL (GL)
- GL1. Require sleep mode features that reduce energy usage by 90% (ST-MT)
- GL2. Work with manufacturing community as in trade associations and interest groups

Technology (TC)
- TC1. User –sensing and user-aware controls
- TC2. Sleep-mode chip or equivalent design standard
- TC3. Preset sleep mode to energy efficiency best practices
- TC4. Sleep mode more responsive to late night network admin. updated
- TC5. Video games with sleep mode are also losing score
- TC6. Google AP to reset sleep mode

R&D Program (RD)
- RD1. Optimize user interface
- RD2. Understand how users might use EGiPC (?)
- RD3. Behavior economics for how people use devices
- RD4. User sensing controls – underway @ TV mfgs, however this R&D is not accessible for collaboration
- RD5. Accessible and simple interface controls
- RD6. Network management for computer networks
- RD7. Software compatibility with stand-by modes
- RD8. R&D for TC4.
- RD9. R&D for TC5.

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

DC Power Source

GAP (GP)
- GP1. Lack of DC network infrastructure
- GP2. Access to DC powered end use
- GP3. Evidence that DC has predictable energy savings benefits compared to AC, and under what conditions

GOAL (GL)
- GL1. Develop access to DC power sources to simplify AC/DC conversions and reduce losses (MT-LT)
- GL2. Work with state/local entities to invoke codes and standards

Technology (TC)
- TC1. Standard DC system products for voltage conversion, facility level distribution and device connection
- TC2. AC equipment adaptor for DC power
- TC3. Buildings wired with AC and DC power
- TC4. DC to DC "transformer"

R&D Program (RD)
- RD1. Direct PV to DC equipment integration
- RD2. DC safety
- RD3. Explore DC appliances with speed control
- RD4. DC loss reduction – basic R&D
- RD5. Power line carrier performance over DC lines
- RD6. Data center requirements for DC only - underway @ EPRI
- RD7. Research how much "stuff" in home is DC vs. AC at the core
- RD8. Universal plug adapter for DC – underway @ EPRI
- RD9. UPS – PV integration (large or small)
- RD10. Higher voltage conversion AC as an alternative to DC (230v) – underway @ EPRI

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

Use and Virtualization

GAP (GP)
- GP1. Standard calculation methods to predict savings
- GP2. Standard approaches to maintain reliability and performance with reduced energy use

GOAL (GL)
- GL1. Create advanced internal (to the device) energy management systems (virtualization) to reduce energy usage (M)

Technology (TC)

R&D Program (RD)
- RD1. Info display @where?
- RD2. More efficient server use
- RD3. Ergonomic research on right sized TV & computer display
- RD4. Visual performance impacts with micro-screens
- RD5. User comfort with VR goggles @ MIT Media Lab
- RD6. Information synopsis fo energy savi
- RD7. Integrate cable, TV and phone to the internet
- RD8. Optic nerve connect @where?
- RD9. Artificial intelligence to summarize DC current accurately (?)
- RD10. Improving information management
- RD11. Better awareness of energy use of googling e-mail, etc @ LBNL
- RD12. LBL- research on network/we energy usa same as RD

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

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Product/Service Area: ELECTRONICS 2/2

Component Level Efficiency

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

GAP (GP)
- GP1. Disclosure by component and system manufacturers of how interactive effects increase or cancel out energy savings

GOAL (GL)
- GL1. Development of low loss components for electric devices (example: substitute LED lighting for fluorescent back light in LDCD TW) (MT)

Technology (TC)
- TC2. Optoelectronics/ Photonics
- TC1. Tools for modeling component interactive energy impacts

R&D Program (RD)
- RD1. Integrated solutions for device component on/off state
- RD2. Broad research on component level efficiency opportunities in electronics
- RD3. Power supply efficiency @ PIER
- RD4. Memory efficiency @ SanDisk, others
- RD5. Chip efficiency @ AMD, Intel
- More awareness of energy of plug-ins
- RD7. More simple and more energy efficient PCs that still meet needs of 70% of users @ Dell, HP, Apple?

Complete Electronic System

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

GAP (GP)
- GP1. Needs an interface to the smart grid feature
- GP2. Turn off all home electronics w/o disrupting functionality – smart strip equivalent software or chip that can be built into any product
- GP3. Make saving energy without sacrificing user experience a CEO goal

GOAL (GL)
- GL1. Reduction of 50% in energy usage based on today's performance (MT)

Technology (TC)
- TC1. Benchmark high-performance (energy and user experience) products in each category – e.g., TVs, video games, DVRs, etc.
- TC1. 10 year goal
- TC2. Optoelectronics/ Photonics
- TC3. Thermometer heat recovery for near zero appliances
- TC4. Software optimization to drive system efficiency
- TC5. Super efficient TV/display
- TC6. 20 year goal and 90% reduction in energy use
- TC7. Efficient set – top box
- TC8. Design mass software for efficient operation
- TC9. Super efficient desktop PC
- TC10. Super efficient servers

R&D Program (RD)
- RD1. Integrated design @ mfgs.
- RD2. Broad research on system – level efficiency opportunities in electronics
- RD3. Integrate algorithms with device architecture @ NetApps, others
- RD4. Rebound effect – which technologies are most susceptible? -@ behavior, M&V specialists

Interlock Devices to Manage Energy Use

Legend: TC Technology Gap (R&D need); RD R&D Gap (No known R&D); RD Current R&D (R&D underway); Comment

GAP (GP)
- GP1. Convenient not inconvenient for users
- GP2. Designed in, not added on to systems

GOAL (GL)
- GL1. Develop low cost systems that permit "quick" adoption (ST)
- GL2. Provide incentives to help bring devices to market

Technology (TC)
- TC1. Standard interlock systems & components available to OEMs for their products

R&D Program (RD)
- RD1. Automated systems to shut down all electrical devices @ various products
- RD2. Behavioral issues/opportunities for next generation of "smart homes"
- RD3. Use of hotel keys to activate room power @ commercial products
- RD4. Requirement standards for sleep modes/stand by @ CEC, PG&E consultants, LBNL, ENERGY STAR

Product/Service Area: Heating, Ventilation, and Air Conditioning (HVAC)

Low-carbon, sustainable, high-efficiency products and systems that automatically diagnose, predict, and maintain high efficiency throughout the product life cycle without sacrificing amenity or service delivery

GAP (GP)

- GP1. Trained technicians
- GP2. Don't currently have "on-board" diagnostics or data streams to collect
- GP3. Don't have redundant or corrective hardware
- GP4. Not tied to building needs/loads
- GP5. Doesn't communicate (2-way) well with building controls relative to performance issues in equipment and systems
- GP6. Don't currently optimize use of ambient or indoor conditions, e.g., economizer, indoor ventilation controls, heat recovery
- GP7. Current high-energy use for distribution of heat and cooling beyond actual vent need

GOAL (GL)

- GL1. 100% of new construction self-diagnosing controls for the packaged HVAC unit (ST)
- GL2. Predictive maintenance in 100% of new sales (ST)
- GL3. Economizer controls & systems (seals, actuators, dampers) that are reliable & effective (ST)
- GL4. Functional performance test definition for factory testing (ST)
- GL5. Variable speed control on ALL systems, fans, compressors, pumps, etc. (ST)
- GL6. Ventilation/temperature/humidity delivery matched to actual uses at granular level so controls can be designed appropriately with monitoring (MT)
- GL7. Intelligent controls connected/communicating with buildings & spaces so unit delivers only what spaces need (MT)
- GL8. Predictive controls to optimize operation (MT)
- GL9. Initial self-healing/correcting (MT)
- GL10. Pattern recognition/learning system (MT)
- GL11. Non-vapor compression cooling (S.S. or Evaporative) (LT)
- GL12. Packaged equipment (up to 20 tons capacity) for 100% of new construction, to capture all lost opportunities in the new and replacement market (LT)
- GL13. Delivery of only what the space of occupant needs (LT)
- GL14. Controls to meet indoor air needs – no excess vented air beyond occupant needs (LT)
- GL15. Intelligent Systems with predictive, diagnostic controls & self-healing processes (LT)
- GL16. Maximum efficient distribution of HVAC (don't use ducts if you don't need them) (L)
- GL17. Work with manufacturing community as in trade associations and interest groups

Technology (TC)

- TC1. User-aware & self-diagnosing controls for the packaged HVAC unit
- TC2. Predictive maintenance
- TC3. Reliable & effective economizers controls & systems
- TC4. Variable speed everything with low cost, high reliability
- TC5. Fast, accurate controls for enthalpy and air flow
- TC6. Wireless controls that meet or exceed all standards for wired controls – move to market case study
- TC7. Hybrid vapor compression / evap. cooling systems and sub-systems
- TC8. Desiccant cooling (if shown to be more viable than in the past) – not applicable in this climate, small market niche
- TC9.User Aware, self-program thermostat
- TC9A. User notification of status
- TC9B. Predictive energy use, alerts when not meeting targets
- TC10. CO_2 heat pump/A.C.
- TC11. Self optimizing controls
- TC12. Expand spec regular use of closed loop controls
- TC13. Need to downscale what's available on big chiller for smaller units and integrate with maintenance systems
- TC14. Some research on neural Nets etc. not conclusive – need more algorithm development
- TC15. Indirect EVAP with thermal mass/night flush
- TC16. Equipment rack with water cooled – high (delta)T low flow
- TC17. Heat recovery ventilation as primary house heat
- TC18. Geoexchange with HRV (may be abandoned)
- TC19. HPWH, heat recovery for whole house heating
- TC20. Retrofit variable air flow system wireless,
- TC21. Retrofitable radiant heating , cooling in residential, commercial, industrial

R&D Program (RD)

- RD1. (GL14) Heat recovery optimization routines such that economizer are not impacted
- RD2. (GL14) No current MTBF testing, case (Title 24 goal for 2013)
- RD3. Hardware there, need more reliable controls FDD at smaller scale, market
- RD4. Some research on neural reps etc. not conclusive – need more algorithm development
- RD5.(TC1) Hardware available, software development needed (Purdue)
- RD6. (TC1-TC3) BPA RTU now testing simple FDD and RTU sequences
- RD7. (TC4) Make ECM motors bigger and do belt drive
- RD8. Research to reduce maintenance, WCEC, NIST, ETO
- RD9. Drop-in ECM motors for residential, need furnaces, case studies, savings, etc.
- RD10. (TC1-TC2) ACRx Swentinel by CEC Pier field study
- RD11. (TC5) Reliability of enthalpy controls – underway @ NBI
- RD12. (TC10) Condensing gas – Pak RTU, NRCAN, CEE
- RD13. Develop load based lab tes for RTUs (Ashrae Rtar 1608).
- RD14. Fault response on compressor related to US companies
- RD15. Field test variable speed HP, EPRI test underway, URF, Daiken
- RD16. (TC13) VRF, more informa about energy use, improving con
- RD17. (TC4) Better mini-split controls VRF
- RD18. (TC12) Water-based VRF systems to incorporate geothermal with VRF
- RD19.(GP7) Solutions are there need more accurate modeling to compare systems eas
- RD20. (TC15) Tied building model to energy use for better simulation
- RD21. (TC16) Field M&V test for zoning savings
- RD22. (TC20) Modularize grocer waste-heat recovery to space heat, case study needed
- RD23. (TC11) Geothermal bore testing for different boring technologies performance, integrating into the building structure
- RD24. (TC14) More variability automatically in simulation for more realistic systems modeling

Legend

- TC – Technology Gap (R&D need)
- RD – R&D Gap (No known R&D)
- RD – Current R&D (R&D underway)
- Comment

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Product/Service Area: Sensors, Meters, Energy Management Systems 1/3

Smart device – level controls responsive to user and environment

GAP (GP)

- GP1. Many stand-alone devices run uncontrolled with no occupant present. Also deliver too much heating, lighting, etc.
- GP2. Cost to add-on sensors is high (e.g., install an occupancy sensor for a light fixture)
- GP3. Central EMS control is expensive and often not responsive to users
- GP4. "Dumb" devices are not much fun
- GP5. Need low-cost control capabilities
- GP6. Standardization of protocols
- GP7. Sufficient intelligence somewhere in the system to manage conflicting inputs
- GP8. Consumer-oriented solutions which combine multiple needs, energy savings and security, convenience, and other consumer uses
- GP9. Occupant desire for individual/personal control
- GP10. "Automatic", how does the occupant control his/her environment

GOAL (GL)

- GL1. Occupancy sensor controls available in common devices (ST)
- GL2. Standards for electronic devices (ST)
- GL3. Extension of smart controls to lighting and HVAC (MT)
- GL4. Standard practice for all electrical devices that directly serve people includes smart control logic and sensors to modulate energy use to optimally correspond to user needs (LT)
- GL5. Modular generic control/sensor packages are available at low cost (10% of device cost or less) (LT)
- GL6. Modular generic control sensor package responding to occupancy temperature light level, air quality, and user input (LT)
- GL7. User input is standard, cheap, and ubiquitous (e.g., by cell phone, standard IR controller, voice command, or similar) (LT)
- GL8. Stand alone sensors must connect to whole system to enable optimum energy use

Technology (TC)

- TC1. Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input
- TC2. Occupancy sensor integrated into lighting fixtures (stairwells, parking garages, outdoor parking lots, private offices)
- TC3. Sensors that integrate with other control systems (lighting, HVAC)
- TC4. Technology improvements to better modulate, control speed etc., need more use specific devices
- TC5. Open license sensor technologies
- TC6. (GP6) Standardized wireless communications systems, "Wi-Fi, Zigbee, Home plug, Z-wave
- TC7. (GP1) Status reporting feedback so we know operation result
- TC8. Eliminate sensors where data can be acquired externally , enthalpy
- TC9. (GP6, GP2) Testing and certification of equipment to conform to interoperability "EPRI level"

R&D Program (RD)

- RD1. (GP2, GP5) Scan existing ubiquitous technology from cell phones for transformation to new use in this application
- RD2. NETC doing some work on power line carrier to distribute low transmission voltages - could this be used for commercial building voltages? – underway – need to identify NETC (?)
- Comment: To what degree are these simply autonomous agents?

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Easy/simple user interface controls

GAP (GP)

- GP1. Based on manufacturer design
- GP2. Does not consider demographic operability
- GP3. Make user experience as important to EMS manufacturers as it is to Intuit and Sony

GOAL (GL)

- GL1. Survey consumer needs (ST)
- GL2. Support demonstration projects (MT)
- GL3. Create standards (LT)
- GL4. Interfaces need to allow for different levels of sophistication of users (LT)
- GL5. Controls need to connect to large number of devices/features to allow users to address amenity control needs (LT)
- GL6. Control management system should be implemented where appropriate, reflect user/occupant known preferences (LT)
- GL7. Need standardization of communication/control protocols to allow for variety of interface devices and approaches (phones, RFID cards, PCs, integrated amenity control devices, etc.) (LT)

Technology (TC)

- TC1. Industry-wide user experience test standards and minimum performance requirements
- TC2. Energy hub
- TC3. Sensors that optimize lighting, power density based on color temperature

R&D Program (RD)

- RD1. Study of what energy management devices do people actually use?
- RD2. Research on energy savings impacts for energy information display – underway – contact BECC conference organizers to get researcher contact info

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Product/Service Area: Sensors, Meters, Energy Management Systems 2/3

Consumer Energy Management Services

GAP (GP)

- GP1. Homeowners do not have expertise to manage energy (RESIDENTIAL)
- GP2. Very small marginal savings available (RESIDENTIAL)
- GP3. Rates are changing and hard to understand (RESIDENTIAL)
- GP4. Homeowners need to control energy costs and be able to respond to higher rates and changing rate standards (RESIDENTIAL)
- GP5. Lack of energy management expertise (COMMERCIAL)
- GP6. Single sites have small marginal savings (COMMERCIAL)

GOAL (GL)

- GL1. Bundle energy management services for cost effectiveness (ST-MT)

Technology (TC)

- TC1. Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input
- TC2. Internet companies providing energy management software (Google power meter, Microsoft Hohm, cable labs)
- TC3. Energy management services companies (Elations, Sensus MI, Verisae)
- TC4. Interval data analysis tools (Northwrite)
- TC5. IP affordable thermostats
- TC6. Web based home, small commercial energy management systems and services
- TC7. Utility company providing 3rd party energy management software (residential and small business – ACLARA, APOGEE)
- TC8. New utility billing systems to incorporate demand-side customer information into customer account
- TC9. Whole house energy use monitoring

R&D Program (RD)

- RD1. Federal Stimulus funded demonstration projects involving home energy management – underway? - confirm
- RD2. Best Buy has Minnesota based prototype testing and development , includes strategy for extension from current offering to EV wiring, home EMS, energy audits and services, iPhone applications, etc.

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

Low-Cost Savings Verification Techniques

GAP (GP)

- GP1. Need to be able to attribute energy performance improvements and affects
- GP2. Devices for measuring widget performance are currently relatively expensive add-ons that are expensive to retrieve information from
- GP3. No tools for savings verification (M&V)
- GP4. Transform raw data into actionable insights
- GP5. Feedback loops for energy related system design and operation decisions

GOAL (GL)

- GL1. Low-cost savings verification techniques (LT)

Technology (TC)

- TC2. (GL1) Software tools to implement IPMVP (M&V)
- TC3. (GP2, GL1) Air advice had portable system to verify EMS sensors
- TC1. Savings verification monitoring, data collection and transmittal devices on a chip that costs pennies and can be incorporated into any product

R&D Program (RD)

- RD1. (TC1) CEC PIER M&V project for universal software (= Universal Translator project?)
- RD2. Texas A&M - ASHRAE Guide 14 what is R&D topic here?

Legend: TC – Technology Gap (R&D need); RD – R&D Gap (No known R&D); RD – Current R&D (R&D underway); Comment

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Product/Service Area: Sensors, Meters, Energy Management Systems 3/3

Real-time Smart Electric Power Measurement of Facilities

GAP (GP)

- GP1. No standard technology
- GP2. Retrofit is expensive
- GP3. Devices lack intelligence
- GP4. Results can be complicated
- GP5. Consumer are not motivated
- GP6. Transform raw data into actionable insights, consumer knowledge
- GP7. Many existing analysis tools require specialized expert operators
- GP8. Standard benchmarking and comparisons to inform decisions
- GP9. Standard protocols and systems to aggregate low level data into high level actionable knowledge
- GP10. Gather data/intelligence about building use operations, schedules, demands
- GP11. People/utilities/energy managers don't know what to do with data – need better data
- GP12. Better designed distribution panels
- GP13. How to layout sensors and distribution circuits to align with EMS – algorithm layer and physical layout
- GP14. Existing analysis tools

GOAL (GL)

- GL1. All utility customers have networked smart meter in 8 years (ST-MT)
- GL2. Create standards (MT)
- GL3. Numerous appliances and devices have embedded and networked power meters (MT)
- GL5. Legislate compliance (LT)
- GL4. All electric end-uses over 1 kW have embedded and networked power metering in 15 years (LT)

Technology (TC)

- TC1. Data collection, analysis, and customer feedback systems to optimize whole-system energy performance0
- TC2. (GP6) Interval data analysis tools (Northwrite)

R&D Program (RD)

- RD1. Existing (DOE, Smart grid R&D workshop)
- RD2. Standards research - underway @ NIST – priority action group working on standards)
- RD3. Develop metrics for interval data. Related to significant drivers such as time of day, weather, etc., high/low ratios - underway [where?]
- RD4. Low cost, reliable enthalpy sensor – underway @ NBI

Enterprise Energy and Maintenance Management Systems

GAP (GP)

- GP1. Site: common protocols for RTU sponsors
- GP2. Enterprise, communicating data
- GP3. Processing, synthesizing and storing data
- GP4. Integrating energy management into consumer services

GOAL (GL)

- GL1. Integrating energy management into consumer services
- GL2. Standards: IP-V6, Internet Engineering Task Force (ST, MT)
- GL3. Bill to provide list that Wal-Mart uses (ST)

Technology (TC)

- TC1. Enterprise energy management software (many providers, easily 30+ companies)
- TC2. Information technology adapted for energy management players: Cisco, Google, IBM, Microsoft

R&D Program (RD)

- RD1. Develop algorithms/intelligence interface of sensor information with central system – underway @ Cisco, others
- RD2. Development of protocols for security – underway @ ASHRAE (?)

Appendix A4:
Workshop 3 (Market Interventions, Programs, Other Initiatives) (Jan. 21, 2010)

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Agenda

Northwest Energy Efficiency Technology Roadmap Workshop #3
—Market Interventions, Programs and Other Initiatives—
January 21, 2010

Location: NW Power & Conservation Council, 851 SW Sixth Ave., Suite 1100, Portland, OR 97204-1348

Purpose of Workshop Series:

- To develop the framework for identifying, selecting, and prioritizing high-value, energy efficiency (EE) research, development, and commercialization to be pursued by Northwest organizations and agencies

Purpose of Workshop #3:

- Identify known barriers to market adoption facing energy efficiency products and services described by participants in Workshop 1.
- Identify market intervention programs and other initiatives already in place (or in development) targeting the barriers to market adoption.
- Prioritize the most important barriers needing addressed by future market intervention programs/other initiatives and articulate necessary components of these programs.

Thursday, January 21, 2010

9:00 am Welcome and Introductions

- **Jeff Harris**, *Northwest Energy Efficiency Alliance*

9:30 am Background and Context

- **Joshua Binus**, *Bonneville Power Administration*

9:45 am Workshop 3 Process and Goals

- **Tugrul Daim**, *Portland State University*

10:15 am Sub-Group Breakout into Product and Service Areas

Tasks #1 AND #2:

1. What barriers are standing in the way of more widespread adoption of each identified product or service in the Northwest?
2. What market intervention programs/other initiatives are in place (or in development) to address those barriers?

11:30 am Working Lunch – Continue Sub-Group Breakout Session

12:30 pm Energy Efficiency Marketing Program Needs

Task #3: What are the necessary components needing to be developed and/or integrated in future market intervention programs/other initiatives needed in the Northwest?

1:30 pm Review, Discuss, and Revise Results of Focus Question 3

3:45 pm Closing comments, Next Steps

4:00 pm Adjourn

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NORTHWEST ENERGY EFFICIENCY
TECHNOLOGY ROADMAPPING WORKSHOP # 3:
MARKET INTERVENTIONS, PROGRAMS AND OTHER INITIATIVES

MEETING MINUTES

JANUARY 21, 2010

List of Participants	
Name	**Organization**
Jeff Harris	NEEA
Tom Reddoch	EPRI
Jack Zeiger	WSU
Mike Hoffman	PNNL
Jeremy Wilson	PCS UtiliData
Gary Keyes	PCS UtiliData
Todd Currier	WSU
Mike Bailey	ECOS
James Thomas	Glumac
Pete Pengilly	Idaho Power
Rem Husted	Puget Sound Energy
Fred Gordon	Energy Trust of Oregon
Joshua Binus	BPA
Rob Penney	WSU
Carol Lindstrom	BPA
Kim Thompson	BPA
Jonathan Livingston	Livingston Energy Innovation
Mark Brune	PAE Consulting Engineers
Laurence Orsini	PECI
Ray Hartwell	BPA

Project Administration:

Project Manager: Joshua Binus, BPA
Consultant: Tugrul Daim, Portland State University
Ji Sun Kim, Portland State University

Workshop Facilitation: Ndeye K. Fall, Energetics Incorporated
Jan Brinch, Energetics Incorporated

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Welcome & Workshop #3 Overview

HARRIS: Today we will focus on the soft side of emerging technologies. A market needs to be ready to receive them. We need to know the best ways to do this.

Effective marketing is strategic. It leads us to integrating a new product/service and technology into the business cycle. We should be asking ourselves, how is someone going to make money with this? What's the profitable business side of this proposition?

Is this going to fit into an existing marketing and distribution channel? If you have to create an entirely new channel, you better have some big capital resources behind it. How do the technologies fit into a delivery channel or delivery mechanism?

Is there a code or standard that might ultimately be a "landing spot" for this product or service? What are our goals in the market? Is there a specific objective for implementation?

Why has all the great technology not been implemented? We have some solution vendors, ESCOs, service providers trying to deliver, utility program folks, universities, research institutes; all with a broad set of experience. I am looking forward to digging into the answer to the question, why are all the good things not yet happening?

Purpose and Overview of Workshop Process

BINUS: I will be addressing the larger context of this workshop and providing the workshop perspective. The Energy Efficiency (EE) task force, asked Bonneville Power Administration (BPA) and NEAA to get emerging tech programs more closely aligned. Stakeholders support emerging technology and market penetration programs; there is some redundancy, and we want to make sure there aren't a lot of gaps. We are seeking collaboration with the whole region. Many stakeholders make up this emerging tech advisory committee (RETAC). We want the whole region to move forward. By creating a technoplogy roadmap we are able to connect the need to develop continuity between deeper R&D and what's happening "on the streets." We still need to develop an information clearing house that everyone can tap into. Also, at BPA, we need to develop tech advisory groups for specific areas of work.

For this roadmap, we started out by laying out a process. Think of this as a "quick start" roadmap. For this, we come up with something tight, operating towards a deadline of 3/1 to have the roadmap put together. This opens up a portfolio for new R&D projects. If a proposal is submitted and is NOT on the roadmap, it doesn't get funded. New proposals will be funded that are in line with roadmap.

Considering that the first iteration is to be completed by 3/1, there is no expectation that 3/1 is the end. The roadmap will be "refreshed." During the first workshop, we identified drivers that the region will be facing in next 20 years. At the first workshop, people at the table thought about products and services needed. We broke the products and services down and categorized them into two buckets; those that are not available, and those that are not in stores. In the other bucket, we put products and services available but facing a barrier, regulatory/legislative, or PR, or marketing, or other barrier. . Once we had the lists of products and services, we broke into sub-groups. People then started developing performance goals of important products and services and performance goals over the short, medium, and long term.

Yesterday, we looked at products and services, and identified technologies we need to get the products and services on the street. We matched them up with R&D programs that are currently underway, by whom, and gaps in R&D. By identifying what R&D is being done, and by whom, one can easily see the funding source and stream. We did not address products and services that are facing technical barriers.

We will be processing all the information and performing post-workshop fact checking.

Today, we are dealing with products and services that face regulatory, policy, and other market barriers. We will identify existing intervention programs that are addressing those barriers and seeing what the gaps are. Our goal is to identify the core components of future programs and initiatives.

During the fourth workshop on February 5th, we will take all the work completed during workshops 1, 2,and 3 and prioritize energy efficiency research and development programs. The results of this prioritization process will be turned over to those who have attended and participated in the three prior workshops so that they can fill in the gaps and recommend R&D

programs that BPA should include in the energy efficiency roadmap. We need other people to help inform the process, so if you have recommendations, please provide them!

Breakout Group Reports/Findings

Group 1. Building Design, Performance, Envelope

Existing Product and Service Domain: Building Design and Performance

Deep retrofits – commercial, residential and whole house/whole building: No additional discussion

Community Master Planning -
With community master planning, so many players are involved that the barrier is getting people to talk and work together. Getting developers, consumers, government, etc. to work together on a solution. The existing programs being run are, Leaf for Neighbors, private developers, and universities looking at whole campus. These are holistic programs. People need to talk with one another. There are lots of cost issues.

Integrated building design
The problem is the user friendly building modeling tool. We are talking about a lot of formal education programs. There is one Building Simulator Users Group, in Portland. They meet once a month. Another part of problem with user-friendly modeling programs is the need for good interfaces. Talking about bringing together lots of people/professionals with needs and expertise. Need user-friendly modeling tools and the people coming out of college need to be trained. This can be done through professional organizations and by building a simulator users group.

GORDON: We have one group in Seattle.

LINDSTROM: We are exploring messaging for participation.

CURRIER: The utility is approaching the Smart Grid from a command and control. The customers want to control their own world. This could undermine relationship. We need to start designing from the consumer perspective.

THOMPSON: Piggy backing on your idea, how do we relay more info and on what?

GORDON: We are trying things.

LIVINGSTON: Stanford landed a large ARRA project. I look at companies like energy hub and echo factor and they know what people wanted.

HOFFMAN: In my experience, Google and the Power meter are nice. You have to have software that's preprogrammed. It is going to be a hard wired system that will show value to everyone as you go.

Building Envelope -
They are expensive. People will not buy them if they are afraid. The aesthetics are important. We need to bundle with other measures and deep retrofit to make the product more cost effective. Building envelope is more important than double-paned window programs. Bottom line is what we pay for windows if incentives are the same, what's the incentive? Is PNNL exploring bulk purchasing? Need to look at longevity. People will look at them as poor products if the products do not look nice.

Advanced Roofing Materials -
We want to add PV and green roofs. It takes time to do this. It takes time and training to install them and roofers can be sloppy. They are expensive, could require changes in roofing practices. One existing program "Cool Roofs". The product doesn't work here. We should have dark roofs not light ones.

GAF is a roofing materials company. If interested in PV, this might be an opportunity to connect with them on a national level.

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HUSTED: I was part of the group. Maybe we need to talk about roofing shingles.

LIVINGSTON: I was involved in a project with GAF. They are interested in doing roofing.

GORDON: We seem to be able to come up with a window spec.

Residential Shell Upgrades -
Cost amortization is really something that we need to look at again. Customers are not necessarily in line with these. There is the potential for advantages and for an upgrade. This is a mom and pop industry. Don't have that with insulation. There is no reliable quality control. If it's not a code inspection issue there is no certainty of how to make sure this is effective. Code angle needs to be addressed.

Deep retrofits -
Commercial, residential. Need programs that amortize the cost. Loans, buy downs, etc.

IR scanning devices -
The cost is coming down but it's still expensive. To perform IR scanning, you need to be certified to use it. To be cost effective you need to implement measures; ETO is doing some aerial work. use IR after the fact. DAs a diagnostic tool – it's too expensive. But after the fact, as quality control to check the results, that's different. A rating mechanism could be developed. Integrate with program savings to make it cost-effective; target old neighborhoods where housing stock is older and opportunities for savings are there.

Foam wall insulation -
Foam wall insulation is a technical and market barrier. Environmental problems are associated with it. It's not aesthetically pleasing, if it's a retrofit. Environmental impact is a big one and how to integrate foam wall insulation into other building products.

Non-utility weatherization funding -
CAPs, HUD, ARRA funded agencies, federal and state tax credits. Develop systems to track savings. Other opportunity is pro-active engagement with utilities and the chance to get all parties involved. Under APPA funds, DOE published to funds allocated for each area. Money flows from DOE to the state and the state decides how to route it. Everyone doesn't route the money the DOE way. Northwest has been pretty isolated. That might be changing. Identifying Low income only candidates can be difficult. BPA is tracking money and then sends utilities information on which agencies/groups have received funding. DOE is getting ready to deploy teams to the field to help spend the money. DOE scorecard to track velocity and tracking stage-gating. Mitigation teams are being put in place.

GORDON: We are looking at alternatives for electronic motors. We are looking at those as retrofit products. Protor Engineers. It is a variable speed motors.

HUSTED: Puget Sound Energy is piloting

Group 2. Water Heating and HVAC

Product and Service Domain - Water Heating

Residential heating systems will continue to get smaller. A lot of the grand ideas will not see success and for 15 years development will continue.

Heat Pump Water Heaters –HPWH -
Heat pump water heaters market barriers are extensive. Product is not designed for our climate. Controls issues exist. We need to get a product for the Northern Tier that has been field tested. Delivery issues combine with contractor practices that are not in compliance with what we need. Application guidance is necessary. We need a supply chain strategy. Consumer buy-in also play a role in this technology's penetration of the market. HPWHs knock off a big part of the residential heating load. We need to do better testing and gather customer feedback. Let's discover companies that make a good HPWH; and capture the purchasing plan as a part of the total supply chain. Mini-splits and COPs are not entirely known and need to be explored. We should research relationships and perform field testing. HPWHs are a very costly technology priced at $10,000 each.

CURRIER: Did you talk about integrated units with mini splits?

GORDON: Yes, this needs to be explored. If something needs to be field tested, we need to test it.

HARRIS: Tom, I know you are testing and you are experiencing leaks.

REDDOCH: You will lose the war during the in. Our early tests are showing a 40% EE saving compared to the old system. The previous system was a traditional air system.

HARRIS: If it has to be done. There is a major market barrier for training.

Solar DHW for commercial/residential applications -
We need to scope SOLAR DHW out. There's a need for a working product for our climate. ETO has spent a lot of time on this. There are a lot of residential and a few commercial Solar DHWs emerging each year. Our best opportunities lay with new homes and the biggest market is existing homes. Small contractors will find this expensive to do. A mass market will be needed to move this technology. A business model is needed. Small ones are selling in niche markets –Big ones have the loads to use the technology but we need to get them interested. There are some things in terms of innovation that can be done and they may be cost competitive. An industry that wants to sell volume is critical. You can do a program if you want. By engaging ESCO type models we could get large numbers installed if we meet the requirements for a delivery system to make money on volume.

Product and Service Domain – HVAC

HVAC/Commercial variable refrigeration flow – building management -
Do they need any help from "us?" Electric industry wants to know if it's really more cost-competitive. Let's find out savings, build savings into models of how we want programs and then decide if we will explore niche markets? Dorms, MF, commissioning problems, need our attention. Our role should be helping but not leading.

Geothermal heat pumps -

There really is no opportunity here unless you're rich. As conventional heat pumps get more efficient and cost-competitive, the delta is getting small. There are design and installation issues for residential users including sizing, matching, lots of contractor issues and overall many opportunities for screw ups. Outside of Idaho and Montana, no one should buy a geothermal heat pump for a residential setting. There are more opportunities for mistakes. In the Eastern part of service territory, BC Hydro is doing some of this and pondering "who are you going to call?" Only so many drillers with only so many quality people. There are only so many hydro geologic experts. People need to step up. How do you do this with the small scale that's going on now?

Non Vapor Compression cooling systems -
There is direct and indirect evaporative cooling. There are some residential combined systems.ETO is interested in testing pre-cooling for hospitals and data centers. Mostly east of the mountains, we don't have much cooling load. Water use is a big issue. Maybe there's a need to communicate with industry that you need product support. Niche promise on the commercial side, not residential. Desiccant cooling is not appropriate to this climate. Energy Trust is very interested in testing the "Coolerado" product. Maintenance is a concern.. We are talking about demonstration and field tests to communicate to the industry that you need some support. Desiccant combined with evaporative? New generation? Fuel costs primarily gas powered, let's explore substituting one for the other.

LIVINGSTON: Has anyone looked at combining desiccants with "Coolerado"? There is some new work going on in that area. There is a private enterprise.

District Heating and Cooling -

What's the incremental cost of doing DHC vs. CHP? Equipment is getting really efficient. If there are losses with DHC then what are you buying with CHP? Or with DHC? CHP vs. utility generation and what's the value? Austin Energy has been successful. Military bases have had success with CHP, security, and reducing maintenance. Old technologies exist such as the standard model, locally based power plant, heat output for district heating, Baltimore, and other cities are legacy systems. There is no drive to get these out there. The district of Portland strictly uses electric boilers.

HARRIS: I am asking from an efficiency stand point.
LIVINGSTON: There are a few districts heating in Baltimore and the Northeast.

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GORDON: This is hard. We are not sure that it is a regional priority.

Inverter driven heat pump, residential reverse cycle chillers -
This is about new MF buildings and taking advantage of waste heat from garages to heat living space. Technology demos for high rise MF, garages in the basement, waste heat exhaust and demonstrations to make it work. Inverter grid technologies have grid advantages, sweet spot of load, and basic scoping. See if costs can be affordable some day. Main question – can we get large enough home retrofit? New homes yes. This one needs front end research. Given that heat pump rebates are marginal manufacturers should either improve them or get rid of them.

Ductless heat pump water heaters -
HARRIS: The ductless heat pump delivers 70% of capacity. We are doing a test with the Mitsubishi model if someone wants to do it in the US market. Mitsubishi has technology that can go in furnace cabinet. There may be a delivery channel for ductless systems using inverter technology.
GORDON: It may be 50 years.

Low temperature air source heat pumps -
Low temperature air source heat pumps are boutique products. And, the industry has been dragging the products along with no success. Efficiency is difficult with duct size and don't know why we are still talking about this one!! It's a failure.

Floor heating/cooling with fluid -
What are the real savings? Group is skeptical when it comes to new construction yes there are savings, but when it comes to retrofit not so sure. The niche is comfort, not efficiency. Retrofitting has to be done efficiently. There are rare situations where floor heating/cooling with fluid could be valuable. The best thing is to give people opportunities and let them go with it. Fan loads are the real opportunity.

Demand controlled ventilation for commercial kitchen stove hoods -
Technology faces many barriers. There are a lot of locations where the landlord doesn't want to put more money into restaurants. Retrofit barriers exist but demand controlled ventilation units are being installed. A lot of products and we don't differentiate them very well. Need a single rebate for all of it. This is a national issue. To overcome barriers there needs to be a lot of field testing, equipment, and working with Burger King and others restaurant. An aggregated program lies in restaurant marketing. There needs to be a strong relationship with restaurants.

Group 3. Lighting, Electronics, Appliances

Product and Service Domain - Lighting

Solid State Lights - THOMPSON: Lighting – solid state lighting! This is technology where there is pull in the market but not universally. Cost is the biggest barrier because this technology is still very expensive and even as the cost curve is coming down, it still has to come down more.

Performance and quality are still an issue. There have been some failures in the market. We need to address the "black eye" that CFLs got when they first came into the market. Quality is another issue. Depending on the application, people are not used to these colors. In residential applications, the blue-white light is not desirable. Awareness is another barrier, but the applications outside of the niche markets are not there.

The DOE contest has rolled out a "million dollar challenge" on solid state lighting. This Christmas, more SSLs could be found in the marketplace. The BPA energy start grocer program is another example that's focusing on lighting for refrigeration. The Recovery Act addresses streetlight and other lights programs exist elsewhere Comprise

We are seeing municipalities adopt this lighting. There are opportunities at identifying the trends out there. We need a mechanism for benchmarking. There is an opportunity to use SSL technologies for the purpose of holiday light. There is transference across markets that we could pursue. LED lighting is still in the early adopter phase. Opportunities are arising to use SSL holiday lights and other kinds as "training exercises with the potential to transfer across market sectors. Grocery store lighting improvements could transfer to the home.

LED lighting is still in its "early adopter" phase. This technology needs to get out into the broader market and could benefit from word of mouth experience. There is a need to have greater general awareness to have trust in the technology. Let's focus on availability and distribution as the niche providers tend to be more expensive.

Metal Hylide Hybrid Technology – ignored.

Product and Service Domain – Appliances

Wireless Homes -
We see wireless controls as an enabling technology and the benefit is more like a behavioral benefit. We did not spend a lot of time on this. It sets the stage for some effect to decrease. You might see more people using them – but they are enabling. It all depends on use.

Ultra Efficient car chargers -
We put a question mark because we think it is a little ways out. We ID that there is work between and keep them from making penny wise pound foolish. Once that market penetration starts to hit, if there are . Electric vehicles are not yet here. So, there is no end consumer pull around the charger technology. We need to insure that there is a focus on manufacturers and end users working together so that new products are picked up. If they are "after market" products, let's build the products.

Product and Service Domain - Electronics

Data Centers -
We put an explanation point because there is a real need. Data Centers are not easy opportunities to pursue. Data centers are hard to reach the market. Because there is no IT to IT peer to peer engagement, people worried about if up-time and reliability are worth it and resultantly don't introduce risk into their business. If municipal utility management and the IT director are not working with Google the credibility in our value chain is not there. Equipment in place become sunk costs. We need to assure cost-benefit and ROI in this kind of investment. NW power is still too cheap. Let's explore the benefits in consulting service and training, who is available? ASHRAE training is needed. We need to make use of case studies, apply best practices, and bench-marking to make sure the core benefits are identified. Today, all the projects are custom projects.We need to monitor the trends and see if we can pursue a project approach so the burden isn't so great. Focus is on retrofit. Let's take out infrastructure and replace it. Because power is cheap here, focus is on desire, not optimization.

For example, there may be a few large data centers, but there are small data centers all over the place. The IT managers have tons of things to do – they are not getting to their data centers. How do we let businesses "stick to their knitting" and yet help them cost-effectively address energy in data centers?

Data storage is a commodity market, so let's recognize this is going in.

Virtualization and Consolidation of Small Systems –

GORDON: We are doing small server virtualization and rebates.

HARRIS: There is a multitude of small data centers.

HOFFMAN: We need to make the ISP lead the virtualization.

GORDON: Because we have Intel, our goal is to use the Intel model for each agency.

Environmental Interlocks -
Environmental interlocks should be automatic. The barriers are cost. Hotels are the market. People in the room, need to build the case. We have questions about quantifying the benefits, do the costs justify the means? There is fear about customer satisfaction.

GORDON: There are existing custom projects but there is no data in place. Energy Trust of OR has done some work on this. New work should address quantification of benefits. We need some sample projects. Let's contact utilities and efficiency organizations in Europe.

HOFFMAN: Can I suggest you contact companies in Asia and Europe who have been doing work with environmental interlocks?

Smart Strips -
GORDON: We had home energy reviewers note what needs to happen and we need to understand the concept that energy still flows to gadgets even when turned are off. How to know the materials that are needed to help understand that there are smart and dumb ways to use the smart strips. Let's add more strips to the list of items. DVR in the home should be addressed. Sports/Jay Leno – ETO – surveying some plugs. What are the first year savings? Let's round up more people to survey plugs to see what's on them.

GORDON: We think this is close.

GORDON: We were thinking about smart strips for offices. I would love more people to survey plugs.

Display devices -
Display device barriers exist because there is uncertaintybetween knowledge and feedback, There are questions around display device benefits. Will people get tired of the devices and just stop using them? We are unsure of what customers would do and the rates of persistence over time. Pilots around the region are looking at behaviors and behavior incentives. Potential opportunities include scorecards or ways to give people more granular information. We want to cross compare and learn in general.

Prepaid Metering -
Pre-paid metering: When a pre-paid card runs out how to go about addressing social risks? We don't want to freeze the elderly. Salt River Project has a great success story on pre-paid meters; pay ahead, and you are more aware of what you are using. Salt River is claiming 12% reduction in energy usage among people on prepaid metering. There is a need for a research agenda to replicate. There is a need for research to validate these claims. . Tacoma is another place to look for lessons learned. The primary benefits would apply to people having trouble paying their bills (revenue recovery); pre-paid cards for others result in more efficiency. People prefer having the control on the metering so that costs don't spiral out of control. Can this translate into the general population? Utility gets their money up front and in return people receive some control of their use.

HOFFMAN: Takoma has been doing it for a while.

CURRIER: The pre-pay metering target is people. The primary benefit is to give people control and knowledge. The bill reduction we saw resulted from people who were going to pay. Utilities look at prepay as a way to deal with customers. It was not clear whether we could draw conclusions that could lead to more generalized findings.

BINUS: We need to be careful about that. I remember.

Kathy: We did talk about customers.

Efficient home electronics -
For more efficient home electronics we need to address how to shorten up the replacement cycle. Often, energy use is not a primary decision-maker, e.g, picture frame. What's the manufacturer's incentive? If not required by federal/state mandate, why would the manufacturer do it? EnergyStar and other programs designed on a voluntary basis can help. For instance, X-box uses 200 watts and Wii uses 20 watts yet no marketing programs or incentives are discussed.

We should work to quantify imbedded energy throughout the cradle to grave design processes. When making energy wise choices how do we create on the front end before stuff is built and purchased?

Residential swamp coolers -
This technology was added to the list. Residential swamp coolers in mobile homes could work in the Seattle/Willamette Valley area. The goal is to avoid AC load. This is a peak problem. Utah is selling the coolers. They could work here. Gas utilities want them to see residential swamp coolers.Net zero homes and how to knock down capital costs to build extremely efficient homes. There are residential sized units that are expensive now, but could be a solution for the Northwest climate and would sidestep a humidity/mold problem.

HARRIS: It seems like there is a flip side between barriers and opportunities.

HUSTED: Make AC easy and cheap.

Group 4. Machine Drives, Waste Energy Recovery and CHP; Other (Industrial, Commercial, Agricultural, Institutional)

Product and Service Domain: Other

Industrial/large commercial voltage/electric system optimization

WILSON: Currently in the market but for custom applications only. Cost-effectiveness is the key. Discussion of market penetration by way of utilities, and then to their clients (10 MW and up.) There is hesitancy to rely on utilities. Look at payback – 3-6 months – 30 Million KWh/year. How does this technology affect our process/business? Core components – field tests on specific products and processes, such as synchronous motors. Oregon State University has a field testing program. Voltage optimization hasn't been dealt with; dependent on outside vendors. Only one optimization vendor is in business in the NW. Need for M&V across the board – BPA recognizes that to date, this as a custom project. . Subject matter training and demonstration of long term optimization are needed, to illustrate best practices on customer operators and motors. Motors are "slave" to production.

BPA represents a large market barrier, because the time lag in getting funding support leads to disinterest in the market. How to get utilities on board with this? One way is to develop an M&V protocol –illustrating that temperature does not play a role in energy demand unless you're using a heating process. Another market barrier is other equipment installed at a facility; need for voltage regulators otherwise it totally changes the scope of the project.

WILSON: We have worked with utilities and their decision-making time period in this field is 6 months. Bonneville has started a different program with industrial customers.

HARRIS: RTF approves.

WILSON: That protocol was designed for small loads and it needs temperature data. The process people will know the right metric data but it changes from one facility to the next.

WILSON: If they do not have voltage regulator then it is.

HOFFMAN: The transmission guys are afraid of what could happen at peak time.

Consumer education-certification
As structures become better, human involvement becomes more of a barrier. Behavior change in general, and more specifically cultural issues are the problems. This is not a technical problem, but a human one.

GORDON: We are doing things through schools and we give them light bulbs. We play through the education and we get the things done. There is a vendor that will endorse this.

CURRIER: There is a recognition that as the structure becomes better.

HARRIS: Wasn't this about behavior change.

CURRIER: This is a human problem.

BAILEY: The waste water one is a cultural issue, not a technology issue.

GORDON: A lot of what NEEA is deciding to do it that.

Low pressure pump irrigation
There are issues with irrigation pumps. There are leaks and needs to measure benchmarks and to incentivize good behavior. You don't want to reward people for bad maintenance, then pay them to fix the leaks.

Low air flow laboratory fume hoods
Low air flow laboratory fume hoods are used infrequently and when used, they are used24 hours/day and7 days/week,. Occupancy sensors that use low flow devices, reduce exhaust air, or reduce make-up air, could significantly reduce HVAC

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costs. This equipment exists. LBNL has done research, but there is no traction in the market. U of Washington has an aggressive HVAC program.

PRICE: Last time we looked at this, there were OSHA issues.

BAILEY: There are fume hoods with low air flow and some that close . LBNL did some research on it and OSHA is based on an old rule of thumb.

LIVINGSTON: Probably the most interesting thing, is University of Washington has an extensive HVAC program.
HARRIS: We explored a project with Seattle City Light.

Quality assurance and commissioning
What's the role of the utility in making sure equipment is installed properly? What's the role of the utility in assuring quality contractor work? Assure quality contractor work.

Product and Service Domain: Machine Drives

Water and EE initiatives
Most people are trying to tie water efficiency to energy efficiency because that's where the money is.

Low-cost variable speed motors for small appliances
EnergyStar folks are pushing these. There's no manufacturing and no place for NW utilities.

Adjustable speed drives for small power movers
Products exist , as do incentives in the market. Barriers are not just the capital cost; it's the engineering insulation. Need to engage a control technician to make sure the drive works correctly. There's a need for additional niche applications such as the homeowner controlled fan motor with variable speed drive. Product should be able to operate in a manual control mode. Technician should hook it up. Occupant should control it. We shouldn't need an engineer to hook up 1 HP system. There are products that can be retrofit products but we don't know how to do that yet. Proctor Engineering – utility is piloting it. PSEG? Product and incentives available – how to properly applied/install/control? It's a designer issue.

Product and Service Domain: Waste Energy Recovery and CHP

Waste energy recovery
Sounds great. How to do it? Identify the lack of system integration funding. Develop more demonstration projects geared toward cost effectiveness. Barrier is getting the cost right for the application and harnessing commercial/industrial/residential improved interface control. Better interfaces, multiple proprietary systems, bypass automation, home programmable thermostats, are all components for waste energy recovery improvements. Everyone says we'll do this now the task is how best to identify options.

CHP
When it comes to fuel cells and microturbines the regulatory environment is the barrier. The challenge is how to get the financing to work. Are you creating mini-utilities? What to do about net metering? There's an element of shifting risk from one energy source to another.

WILSON: It sounds like mom and apple pie. The issues are multiple. The barrier is not the technology. It is getting the cost combined with a need for improved human interface control. It is interface with multiple complex systems and lack of ease of use. Think of how many MP3 players existed before the iPod.

WILSON: Water and sewage. It is a very specialized market and a market that is reluctant to change and hard to penetrate.

GORDON: We've had weak success doing deployment in water sewage
HARRIS: Is this more like restaurant and you need to engage?

GORDON: I saw a proposal of market transformation for training.

BAILEY: It is an energy management issue.

HOFFMAN: Air bubble.

HARRIS: My experience is that it is a 2-year sale cycle.

Product and Service Domain: EMS

Low cost EE savings verification techniques
Smart Grid customer facing technologies will drive M&V. Barriers include market information, better user interface and driver ease of use while keeping cost down. Looking at existing products like Microsoft Home there is potential to integrate existing technologies into new programs. Low cost self verification should be included in program designs. Bringing in home entertainment/theatre is a great opportunity to put M&V in.

Easy/Simple Controls for Consumer Market
Incorporating easy/simple controls with consumer energy management services faces the barrier of cost for both that we need to get the market to address. There is a lack of standard architectures. Are the products too unique? Products available are Energy Hub, Power Man Tendril; PECI has …air…plus; Microsoft has technologies. Being future oriented the goal is engagement with residential and small commercial customers. Let's pitch a better value proposition. The need is for utility incentives. There are no service providers. While some families don't mind being monitored others want complete privacy. To address privacy, we need to identify a small population who are not averse to having their homes monitored and pursue a cross cutting strategy.

HARRIS: We need to have a value proposition.

LIVINGSTON: Some people are more of the reality TV advocates. We need to have people who are not averse.

REDDOCH: I volunteered at EPRI. I have an extraordinary idea, if you can ID those that would be ready to cooperate and overlay the timings you did some things.

HOFFMAN: Between grid wise and the ASHRAE project, we had 100 smart homes.

REDDOCH: I can see when the washer is turning on.

Industrial energy optimization
3-5 years for great market penetration. There's a "one-up" nature to the programs. Value proposition is necessary. 2011 is timeframe for ISO 5100 the gold standard for industrial energy management. Get simpler tools out there. Larger guys have significant demand; it's the smaller ones that need these simpler tools.

Existing Product and Service Domain: Sensors and Meters

EMS that can interact with the Smart Grid
There's room to make these cheaper and more pervasive. A need is for a value proposition. A future program is an automated DR protocol. Automated demand response will drive people toward these systems. Linking these controls to customer usage data is a need and the essence of the Smart Grid. There are often issues around that data. This is not so much a barrier to the market, but a shortcoming of infrastructure.

EnerNoc is under contract to Idaho Power. EnerNoc offers energy management and monitoring, etc. All commercial/industrial companies can participate.

PENGILLY: We contracted with Interock for large commercial, small industrial DR. The customers can use i . We use it a handful of times.

HARRIS: For our purposes for EE, we need not just data. We need more of these parties that can collect the data and act on it. It is what's necessary I think.

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GORDON: Water heater setback. You need approaches to big energy pieces to force US bureaucrats.

For energy efficiency, moree third parties need to act on behalf of commercial/industrial clients to roll out programs in buildings and bring the value back to building owners.

<u>Smart device controls responsive to user and environment</u>
Architecture is an issue. What's coming along? Japan and China have controls. TVs have an application that can be adapted for smart device controls responsive to the user and the environment. Occupancy sensors are needed that can be used. By getting incentives in the hands of OEMs utilities see who would really go for this and can start to push building up smart device controls.

<u>Air quality sensors control ventilation</u>
Get Trane and Carrier to build air quality sensors into their systems. Simple solution.

<u>Inexpensive end use load monitoring</u>
Utility value proposition should be delivered. There's enough savings in load monitoring to build programs. The disagreement is on what people need. Customers do care about safety, so you are covering a couple of bases. You're better off selling more than less. If you have a spark plug in place – you know what the problem is, now it's about how to know the cause and effect. Safety and security identification of usage patterns.

<u>Real time consumption by appliance</u>
The current systems tend to be complex. Are you picking up the appliance level or the request for the holy grail to come up with it? Nexus and others are working on this. Appliance manufacturers need incentives to encourage them to not only control, but to monitor these appliances. The question is how to bring them together. Should appliances themselves have the real time monitoring equipment already? Are these marketing solutions? No. More thinking should be done to turn real time consumption tools into marketable products and activities.
<u>Residential occupancy sensors</u>
First, get the costs down. Most installs require licensed electricians adding to higher costs. Challenge is how to combine residential sensors when new stuff is installed. Wireless technologies are critical for combining new technologies with existing technologies. The best case will be when hard wire installs are not required.

<u>Smart utility meters for all customers</u>
PGE, Idaho Power, and BPA are all doing things. Not that all utilities are not deploying, but what's the value proposition? When to invest? When is a good time to spend money on this?

HUSTED: We bought one of the first generation products.

<u>Smart charging/re-charging</u>
Manufacturers, and all OEMs, customers, etc., need to come together. This is a "chicken and egg" problem. For the Smart Grid, the problem is how to integrate.. A cost and value proposition should be developed that can be spread across to all stakeholders. What to do first? How to deploy it all at once? Portland and Seattle have 2,000 in each location with charging stations placed in each. What's the efficiency of them? Cost is more on their mind – not efficiency. They are coming to the region and there is the opportunity to get some experience with them. Peaking problem will be exacerbated.

There will be an on-board clock. If you don't have time-differentiated rates, there is not an incentive. Need a full charge, system that needs to talk to it and that's where the smart grid comes into play. That's where the communication comes in.

REDDOCH: In the northwest , there will be 2000 charging stations.

REDDOCH: We have not looked at the efficiency. EE is on their mind but cost is most important. They will have an opportunity to be retrofitted. They are coming to the region. It is an opportunity.

PENGILLY: We are worried about that.

REDDOCH: Charging comes in 3 levels: Level 1 is 120V (3.5kW), level 2 is 240 v (6kW) 440v (35-50 kW)

HOFFMAN: You are supposed to be smart with the timer. There is a spec currently being developed.

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Building Design, Performance, Envelope

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Component of Future Programs and Initiatives
Building Design and Performance						
1	**Deep retrofits - commercial, residential Whole house, whole building**	◆	technical & market	3 to 10 years to become cost-effective. Need market pull by consumers, building industry, contractors, and communities. Disruption of business, high upfront cost.	BPA & utilities Energy Trust CAP agencies AARA - funded agencies State & federal tax credits OakRidge National Lab (ORNL)	Programs to amortize cost: EE loans (low interest) Interest buy-down programs Connection or rate advantages
2	**Community master planning**	◆	market	Need market pull by governments, real estate developers, builders. Zoning requirements, codes, many players.	LEED for neighborhoods Private developers University (whole campus) programs	Holistic approach with all players Legal barriers to shared systems (creating mini utilities) Cross discipline education
3	**Integrated building design (= advanced efficiency and productivity and understanding 1st cost) (commercial) (N)**		other & technical	Building America (U.S. DOE); Savings By Design (California IOUs). Need more user-friendly modeling tools and integration. Engineers, architects, buildings all have different needs/priorities.	Energy trust NEEA better bricks Integrated design lab Building simulated user group Cohos Evamy Ashrae	Design/availability of user-friendly modeling tools Formal education programs (colleges) Cross-disciplinary education at the right time - use professional associations
Building Envelope						
1	**High efficiency windows - more than double pane**	◆◆◆	technical & market	Need new technology, market pull to drive costs down. Questionable longevity of product. Traditional incentives not provided for anything beyond minimum requirements.	PNNL - they are exploring a bulk purchase program. Not cost-effective yet EnergyStar & DOE	Bring cost down - prove longevity Aesthetics and potential increased resale value Codes Market transformation Bundle with other measures
2	**Advanced roofing materials - Reflect PV and Green Roofs**	◆◆	technical & market	Need better materials w/improved performance at lower cost; increased roofing industry acceptance and advocacy, market pull. Safety and training (roofing industry) Questionable durability Could require changes in roofing	Cool Roofs Initiative (CA) GAF Roofing ORNL	Demonstrate/identify benefit to end user Standardized installation practices and education for bundle with deep retrofits to gain cost-effective roofing contractors
3	**Residential shell upgrades (more products/systems) - easy/cheap?**	◆◆	technical & market	Cost, codes, customer and building acceptance, Workers not experienced with installation	Earth Advantage State and federal tax credits Oregon Housing and Community Service	Trade education/training Cost amortization, see #1 (deep retrofits) No big manufacturers No quality control

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Building Design, Performance, Envelope

Existing Product & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Component of Future Programs and Initiatives
AARA groups						
4	**Infrared scanning services**	◆	market	Need increased market pull and availability, reduced cost Expensive equipment, certified technicians required. Has to be integrated with programs.	Energy audit programs (utility and energy trust) AARA groups Trust-Aerial IR	Could be an inspection tool Equipment loaner program Integrate with programs to get cost-effective savings Certification of technicians Whole neighborhood
5	**Foam wall insulation**	◆	technical/market	Need cheap, convenient, environmentally-benign materials Ugly if retrofit.	See #1 (deep retrofits)	Aesthetics Cost/environmental impact must be improved Integration into other structural materials
6	**Non-utility weatherization funding**	◆	market	U.S. DOE (w/ARRA funds) & HUD are providing; not clear if this funding is sustainable. Need lead agencies to drive long-term uptake.	CAPs HUD - LiW AARA agencies State and federal tax credits	Track savings (system) Engagement between utilities with community groups, government programs and developers
7	**Cost-effective residential air sealing - retrofits and M&V**		technical & market	Need technology improvement to reduce costs; increased market pull Inconvenient to homeowner - not cost-effective without tie in to programmatic savings	Check with Affordable Comfort for existing programs & initiatives	Whole neighborhood/targeted homes to decrease wind shift time tie into programmatic savings Targeted approach based on housing stock
8	**Effective insulated window shades**		marketing	Need increased market pull and availability, reduced cost Too much relies on behavior - not practical unless tied into environmental interlocks	Check with Affordable Comfort	

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Water Heating and HVAC

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Water Heating						
1	**Heat pump water heaters with exhaust vent** **Mini split with space and water heat**	◆	market & technical	Need increased market pull and availability, reduced cost Product must evolve Nice[?]: demand management control Need functional product from major manufacturer need proof of savings in our climate lab field consumer interaction price - space Delivery - weight, complexity, contractor practices, training, buy-in service infrastructure	Northern tier specf NEEA on point for region for M1, Puget, PGE promotion BPA, EPRI lab test Major and start up manufacturing Tax credits	Testing United specification - Northern Tier Customer feedback application guidance Supply chain strategy Training
2	**Solar DHW for commercial / residential applications**	Added	market & technical	Need increased market pull and availability, reduced cost. Must be driven by roofing and building industry to achieve broad acceptance. New/existing - first cost Owner issues for new expensive retrofit scale and business model of industry product integration. QCT confidence. Show offers high value site-competitive position Competing products	ET, maybe some more manufacturing innovations - Bradford White Focus on south? Tax credits Commercial - no tenant on spec building Much of commercial: local water heater NREL & CEC PIER	Integrated system w/PV & roofing, incl. cool roofs where applicable Mass market contractor business model Cost reduction Product improvements - plastic? Volvmet Price Target high C/I users Solar ready construction?

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Water Heating and HVAC

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
HVAC						
1	**Commercial variable refrigeration flow Please compact heating recovery multiple for coils. Quiet integrated controls create building ???? System. Offer using EMS to calculate rough submetering costs based on fan coil operating.**	◆◆◆	technical & market	Need technology improvement to reduce costs and ease of application, better documentation of energy savings; increased market pull Established models don't model it yet. Equest will fix this. Saving unknown Very ????? Commissioning/controls design issues Is there higher cost? Is utility rate code issue: refrig volume/safety needed. Seattle code issue of economizer implementation work underway.	Several active manufacturers. Many installed utilities support as single [?] refrigerant flow.	Find out savings Build into established models See if further utility role needed Installation QC training.
2	**Geothermal heat pump for residential and commercial use**	◆◆	market & technical MF & comm	Need increased market pull and availability, reduced cost. Not enough degree days outside of Idaho, MT and spots. Insurmountable capital cost. Poor standards for design and install. Cost limited number of experts. Niche product. Complexity-vendor culture/exaggeration.	BC Hydro does hybrid ground/air ETO has prescriptive C/I, low offer for res.	Res. Focus on cold climate CFI - training get A&E's familiar with hydrogen-experts [really?]. Also drillers. Trade ally/cert.
3	**Non-vapor compression cooling systems (50%<)**	◆◆	technical & market	Need technology improvements to improve performance under peak temperature and humidity regimes; industry acceptance and uptake. Not currently accepted by mainstream HVAC industry. Some commercial product controls and package should evolve Maintenance issues - cost, mold issues. Tech support from manufacturer. Water use. Target 24/7 East side.	ET try to demo Colorado. Others: custom measure. Distributors in NW exist - few if any sold. CA demo work at home scale & Western Cooling Challenge Coolorado still working on package product. Products from Australia and Israel	Demonstrations/field test Communicate interest and support needs to manufacturers and distribute Follow success elsewhere.

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Water Heating and HVAC

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
HVAC (continued)						
3.1	**Desiccant cooling**	Added	technical	Need cheap, convenient, environmentally-benign materials, no entrainment of fluid into air stream	PAX Scientific attempting new hybrid approach	Bottom up effort to identify needs, markets, likely cost effectiveness w/mature product Determine if there's an application in non-humid climates w/new hybrid approach
4	**CO2 refrigeration or other alternative refrigerants**	◆	technical & market	Some products & equipment entering the marketplace in Asia. More alternatives and compatible equipment needed. Also need market pull in U.S. to drive adoption. Climate issue-need to assure best energy outcome as it is solved. Not economic, not market-ready	Manufacturer/legislator/regulator driven Conversion drives market opportunity	Do we need to engage? Assess potential for energy savings, cost effectiveness, non-energy benefits
5	**Distinct heating and cooling Plus CHP helps economics Balance heating and cooling**		market & technical	Market penetration inked to community master planning $ planning horizon, make sense a few places, tenants show up later. Front end cost, stayed implementation. Complex	Fit: new planned development expand existing loops Relatively common in Scandanavia - elsewhere in EU?	Need to support strong urban planning initiative from cities Someone needs to pay long term infrastructure. Change to program performance metrics
6	**Residential reverse cycle chiller**		technical & market	Need better performing, more reliable equipment at reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance. For MF with garage in basement for hot water Small niche, nice product. Is there enough heat?	BPA demo equipment available	Demonstrations Question: Is there enough heat?

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Water Heating and HVAC

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
HVAC (continued)						
7	**Low temperature air source heat pumps**		market & technical	Need increased market pull and availability, reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance. Competition from ductless and inverter driven Delicacy of savings to duct sizing and commissioning Niche market in NW - product tending, complicating field testing No mass manufacturing	OR tax credit NEEA - DHP	Is this a priority Focus on low temp ductless minis?
8	**In-floor heating/cooling (electrically driven) – with fluid Plus water loop saves space**		market & technical	Need increased market pull and availability, reduced cost. Must be driven by equipment manufacturers & building industry to achieve broad acceptance. Comm. small and growing Residential - trivial custom building trades know air Cost more Niche = comfort loads are shrinking Few heat/cool products. Heating mostly gas??? or propane Energy savings = fan load	Commercial in custom programs Eligible (as is anything) for ET and Energy Star, but mostly GHG Maybe driven by ducts inside in code	Is this an electric issue? Future = gas wall hung boiler R demos where electric now homes exist C radiant in 60-70 past code-panels Opportunities to drive down equipment and system cost - but is that our job?
9	**Demand-controlled ventilation for commercial kitchen stove hoods**	Added	market & technical	Need increased market pull and availability, reduced cost. Must be driven by local governments & industry to achieve broad acceptance.	ET prescriptive - find out uptake Puget custom RTF working Variety of different products CEE reviewing	Understand product differences and savings National level issue Field tests, modeling, spending more time at engineering level understanding Get a bunch on Strong multilevel restaurant marketing programs Work on no AC home
	Inverter Driven res whole house heating pump	Added		First product from Nordyne. Performance untested locally Price increment unknown Test difficult Motor Cost	Nordyne product others looking Big buzz at CEE X??? Motor cheaper alternative Interims product Mitsubishi has the technology, not have yet.	Basic scoping tech readiness & cost analysis for MT field test

Water Heating and HVAC

Existing Product & Servce Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
HVAC (continued)						
	Swamp cooler or cooler?????			Style maintenance in nominal cooling load Fear of ho ac	Utah sells Works in NW No focus	See Item #3 above
	Minisplit **Res space and water heat**			No standard kit LOP implications unknown	Maybe in other countries	Explanation field test
	Whole house in p w S&W heat [?]			One unit on the market	EPRI is testing	H couple field test

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Market Intervention Programs and Other Initiatives for the Existing Products and Services

EMS, Sensors, and Meters

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
EMS						
1	**Low-cost EE savings verification techniques**	◆◆◆◆◆	technical & other	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 18 to 36 months. Barrier is development and integration of verification technologies into systems and products, plus lack of market pull by utilities and other EE stakeholders. Need better user interface, ease of use while keeping cost down and reducing cost.	Regulatory/utility global standard for EM&V = 1PMVP Products: (all available now) Verdiem Energy Surveyor - creates own baseline - utility grade capability? Scientific Generation Inc., baseline and measure prioritization Air Advice - mesh sensors for baseline creation	Enhance Hohm, Google Power Meter to incorporate these capabilities Make these approaches part of utility programs, available to consultants Leverage often in-home service like TV, home theater, misc., electrical work.
2	**Easy/simple consumer (user) controls**	◆◆◆	technical & market	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on. Need to develop utility/appliance communications standard interfaces	Products (available now) Energy Hub Power Manual Tendril	Need long-term engagement from residential and small commercial customers Need value preposition for end-use customers and service partners Need utility incentives
3	**Consumer energy management service(s)**	◆◆	market	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on. Move sophisticated large EMS tech, baseline/EE prioritization (measure-maintenance) and failure warning to medium and small EMS systems.	These products and services are linked or should be as future programs PECI "Air Care Plus" - optimizes roofer equipment Field Diagnostics Microsoft "Hohm" Google "Power Meter"	Need residential service providers (all are ??? Now) Educate service providers on value preposition Find families "Neilson families") who are ok with continuous monitoring projects at their homes - as test bed for range of EE products
4	**Industrial energy optimization**	◆	technical & market	Pilot and special cases at present. 3 to 5 years for greater market penetration & ease of use. Barrier is development of highly reliable, low-cost technologies, plus market pull for their development.	Pilots @ LBL - Aimee McKane NEEA program (now): Continuous Energy Improvement One to Five (now) BPA and ETO - energy management programs for industrial sector	2011: ISO S1000 will establish highest level for industrial energy management Now to 2015: need simpler tools deployable for small/medium industrial segments

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

EMS, Sensors, and Meters

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Sensors and Meters						
5	**EMS that can interact with the Smart Grid**		other & technical	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on. Education of value proposition relative to DR/EE/privacy for large --> small	Products (now) Energy Hub EcoFactor Tendril See Items 2&3 above	Need value preposition for utilities and consumers ADR - empowers utility for DR Need to link EMS to real time and historic consumer usage data Leverage free devices/services from DR companies --> roll out EE service piggy backed on DR
1	**Smart device level controls responsive to user and environment**	◆◆◆◆◆	technical & market	Entering the market now. Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier is standard architectures for these to operate in / on. Not adopting/reviewing Asian innovations	Products (now) BiLevel lighting (stairwells, garages, offices) - BPA and other programs - lamar and other manufacturers Small plug strips: residential and commercial (cubicle) occupancy sensor - various manufacturers TV ambient light sensors - dimming - various manufacturers	Import solutions from Japan, China Build proximity sensors into TVs to sense if anyone is in room turn off screen if not (manufacturers - Sharp, others) Incentives for controls built into OEM products
2	**Air quality sensors control ventilation**	◆◆◆◆	technical & market	Need market pull & industry advocacy to drive greater diffusion & adoption. Getting HVAC manufacturers to license/install best sensor tech	Products (now) Air Advice - monitors CO2, VOC Various other manufacturers	Incent big players like Trane, Carrier to build these sensors into HVAC system to drive broad deployment
3	**Inexpensive end-use load monitoring**	◆◆◆	technical & other	Plenty of room to make these cheaper and more pervasive. Expect this to come with customer-facing smart grid applications in 18 to 36 months. Barrier is standard architectures for these to operate in / on. No communications standard to move data to online from devices	See EMS Items 2&3 Products (now) Obvious Veris Picowatt The Energy Detective Blue Line	Need utility value proposition to drive future program This may be non-energy driven like safety, security

EMS, Sensors, and Meters

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Sensors and Meters (continued)						
4	**Real time consumption by appliance**	◆◆	technical & other	Current systems are complex and unreliable. Expect this to come with customer-facing smart grid applications in 12 to 24 months. Barrier has been development of real-time energy signature recognition for specific appliances & systems. No inexpensive sensors	Products - have this capability now Kill A Watt Energy Hub Pics-Watt	Need re??? On how to ??? Customers with information Incentive/encourage appliance manufacturers to link monitoring to direct control capabilities Explore trade-offs: smart outlets vs smart appliances - which costs less? Develop better "smart" control algorithms and software
5	**New commercial building electric metering, measurement protocols, and benchmarks**	◆◆	other	Need on meter M&V SW	Program - Office of the Future (NBI, SCE, etc.) Products: Dent, Veris meter-grade monitoring and sensors See Item 1, EMS	Incent software for smart meters to do benchmarking, EM&V Need lower cost solutions Link to continuous commissioning
6	**Residential occupancy sensors**	◆	market & other	Need market pull by builders and remodelers, consumer & government advocacy to drive greater diffusion & adoption. Requires work with manufacturers	Existing utility programs? Appears not cost-effective for utilities now	Cost reduction strategies - installation by electricians drives cost - so combine with other in-home service - see EMS Item #1 Also incent installs as part of comprehensive retrofit or any light?? Install Look at other ways to adapt commercial programs for residential
7	**Smart utility meters for all customers**	◆	other	Entering the market now. Barrier is utility & regulatory engagement. No value added for EE/DR without control	Programs (form AMI) PGE Idaho Power BPA	What's the value preposition for the majority of utilities?

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EMS, Sensors, and Meters

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Sensors and Meters (continued)						
8	**Smart charging recharging**		technical & market	Need improved system performance & integration into vehicles, charging stations, and residential infrastructure. Must be driven by customers', auto manufacturers', commercial facilities' and government agencies' requirement to achieve broad acceptance. Plug standard for charging/power and comm.	Pilots only - no programs yet Portland State with RMI PGE and ShorePower PNNL-research	Link in-home EMS/metering products with charging capabilities Establish costs and value proposition Chicken-egg problem (split incentives) Which comes first - vehicles or infrastructure?" What will drive utility equipment installations?

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Lighting, Appliances, and Electronics

	Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Lighting						
1	**Solid state lights**	◆◆◆◆◆◆◆◆	technical & market	Primary technical & market barriers are reflected in Haitz' Law - lamp performance improving 30X and cost decreasing 10X every ten years. Cost Performance/Quality Consumer Awareness Awareness White color Color Retension Reliability	Energy items Christmas lite fact sheet Christmas lites safety cost color green image DOE funding and focus on solid-state Million dolalr challenge US DOE BPA/PEC/utility incentives, gas station refrigerated AARA funds fro streetlight projects DesignLights Consortium	Incentives for street lights/deemed savings Avoid bad products/black eye Signage on grocery LEDs Consumer incentives to offset cost (resdiential) distribution and availability get beyond niche Benchmarking and product recommendations for streetlighting (right product, right application) Program: solid-state "training wheels" e.g., holiday lights to create halo into new product Cross the chasm - word of mouth/referral approach to build awareness and build demand Affinity grasps built around early adopters Awareness - bulding of benefits
2	**Efficient metal halide fluorescent fixtures**	◆◆	market & technical	Need increased market pull and availability, reduced cost. Must be driven by lighting manufacturers, specifiers and contractors to achieve broad acceptance. Cost Qualtify benefit Awareness	Utility incentives	Turn off lights and plug load at night, leaving Couch potato ease - no messy wires Enabling technology [This is confusing, in part because no one seemed to know what the original product description meant]
Appliances						
1	**Wireless homes**		technical & market	(Assuming this means wireless control, not wireless power distribution.) Needs technology development, market pull by consumers, builders, and appliance manufacturers. Awareness of benefits		Refer to Tab 5. EMS, Sensors & Meters

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Lighting, Appliances, and Electronics

Existing Product & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Electronics						
2	**(Ultra Efficient) Car Chargers**		technical & market	Need improved system performance & integration into vehicles, charging stations, and residential infrastructure. Must be driven by customers', auto manufacturers', commercial facilities' and government agencies' requirement to achieve broad acceptance.	EPRI - work with auto makers	Upstream influence Policy (standards) Manufacturers, e.g., keep inefficient charges from hitting market Certification program (e.g., Energy Star) Upstream to mfg and pucles ALA NEEA/ECOs 80 Energy Star certification Upstream intervention - avoid introduction of low-efficient chargers Policy/standards/lobbying
1	**Data centers**	◆◆◆◆	other & technical	Need IT and data system specialists to align their activities with those of facility design, operation & management specialists. Local small utilities lack credibility to advise Replacement/retrofit costs - when used equipment is sunk cost	US DOE T=ITP tool resources certificat. Training "L-prize" BPA/utility custom HVAC/virt. Incentives PG&E Data Center Efficiency Consortium (still active?)	Utility and corp and consultant training Deemed savings for virtualization and power conversion More resources on design, rather than optimization LBNL resources ASHRAE training Awareness outreach to target audience Commodity market - tough business case Case studies from demonstrations Create target data center program IT, peer to peer interaction
1.1	**Virtualization and consolidation of small system**		technical & market	Need better systems & system management applications to meet reliability and security requirements. Must be driven by client, industry, and government agencies' requirement to achieve broad acceptance.	Industry pull-cost/benefit Q: custom projects BPA Are there utility incentives? EPRI programs in data centers PG&E Data Center Efficiency Consortium (still active?)	Build on core concepts from PG&E Data Center Efficiency Consortium and other initiatives listed to the left.
1.2	**HVAC**		market	Need market pull by clients', industry, and government agencies' requirement to achieve broad acceptance.	Custom projects	

Lighting, Appliances, and Electronics

Existing Product & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Electronics (Continued)						
1.3	**Power conversion**		technical & market	Need improved system performance & integration with / into data center hardware to meet reliability and energy savings requirements. Must be driven by client, industry, and government agencies' requirement to achieve broad acceptance.	Custom projects	
2	**Environmental interlocks - hotel key locks**	◆◆◆◆	market	Need broad industry awareness of system performance and benefits to drive market pull. Customer acceptance (e.g., guest dissatisfaction Retrofit costs to hotel quantification of benefit	Custom projects/incentives for hotel	Expand past hotel to office, home, etc. Address hotel management concern of risks benefits Linking office occ. Sens. To HVAC smart strips Pilots to gather data - quantify Cost/benefit Qualitative Guest acceptance
3	**Smart strips - turn off appliances when not being used**		technical & market	Need improved system performance & integration into home & office hardware. Must be driven by customers', commercial facilities' and government agencies' requirement to achieve broad acceptance. Quantify savings Not enough load on plug other than DVR and games Distribution and availability Distribution and availability Verifying savings	Deemed savings RFT provisional $15, 100 kWh/yr = 1 digital frame	Utility incentives for smart strips ~$15/per Awareness effort . . . Phantom load the true cost of your gadgets Direct install? "How to" for end users - education to optimize use Survey plug load in power strips Explore opportunities beyond "just a smart strip" given initial weak findings from ETO. In particular, look at semi-dedicated strips for home entertainment or computers where a certain level of power and operating hours are "givens"

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Lighting, Appliances, and Electronics

Existing Product & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Electronics (Continued)						
5	**Alt: pre-paid metering**		other & technical	Must be driven by utilities', regulators', and customers' interests and requirements. Don't freeze old people Awareness and availability from utility	ASRP success, study done RPT INZ-3 months-12% Tacoma Power tried it - revenue recovery - low income like control Salt River Project as example - low income focus	Utility cash flow less risk Good for low income transient - no down payment Utility offering and infrastructure (billing, charging cards, kiosks, monitoring devices)
6	**Cradle to grave design**		market & other	Needs market pull by consumers, government agencies and designers to achieve broad acceptance and adoption. Quantify embedded energy Energy-wise choices "eat" margin for manufacturers - no thought beyond cost of sales		Total cost of ownership as credible decision influence (sales tools, point-of-purchase, etc.)
6.1	**Electronics**		market & other			Refer to Tab 5. EMS, Sensors & Meters
6.2	**Sustainability**		market & other			
7	**Efficient home electronics**	Added	technical & market	Need improved subsystems & integration into products. Must be driven by customers', retailers' and government agencies' requirement to achieve broad implementation. Useful life of existing in-home electronics Awareness (consumer) of energy impact of devices Manufacturer incentive to integrate energy - use considerations in design	Certifications: e-star ratings Policy-making integrate energy use into Epeat (continue) NEEA - Consumer Electronics Program NEEA - 80+ Program	X-Box = 200W = 3/4 Fridge WILL = 20 watts Explore approaches to partner with Consumer Electronics Assocation, which has taken a hard line in California and w/Energy Star - try a "détente" model?

Existing Product & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Electronics (Continued)						
	Sleep Mode	Added		IT Network administration distrust sleep mode on PCS Home owners want instant on		
	Day lighting	Added		Costly-retro glare	Utility incentives Day lighting/integrated Desken Labs	Promote productivity increases, tie to bottom line

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Other (Industrial, Agricultural, etc.), Machine Drive, and Waste Energy Recovery/CHP

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Other (Industrial, Agricultural, etc.)						
1	**Industrial large commercial voltage/electric system optimize**	◆◆◆◆◆◆	market & other	In market but for custom applications only. Not clear how cost effective this can be on the average, and how it fares relative to other energy efficiency retrofits at the same cost.	BPA - Energy Smart EPRI - Voltage Optimization - pilot "Green Circuits" Studies not to slow down early ????? NEEA - DEI study and Voltage Optimization Proposal	Field testing --> on long term impact on industrial systems and motors subject water training --> utilities and industrial users Case studies on proven results Demonstrate no operations impact
2	**Consumer education - certification What is this? Not enough information**	◆	market & other	Need engagement of government plus NGOs and/or utilities to drive initiatives. Public support or acceptance is vital.		Need M&V standards to evaluate performance
3	**Low pressure pump irrigation (Agriculture), existing but not sufficient**		market & other	Need engagement of ag industry, service providers & government to drive initiatives.	Incentives for efficient motors, VFD???	Link with water utilities, agricultural industry and education organizations (WSU, for one) Study end-users to understand underlying needs and decision criteral
4	**Low air-flow laboratory fume hoods or Smart hoods --> close sash when not in use**	Added	market	Must be driven by health & safety regulatory agencies in concert with universities & industry.		Set up M&V standard Case studies, demonstration projects Need incentives, installation support specific Target Market Segment
5	**Quality assurance and commissioning**	Added	market & technical	Need alignment of government plus building industry, property management companies, building owners, as well utilities and other intermediaries to drive initiatives. Public support or acceptance is vital. California is active in this domain.	Building code standards Owner --> responsible for project Quality/commisisoning	Installation verification Issue of how to evaluate "appropriate for use" Feedback --> vendor performance program

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Other (Industrial, Agricultural, etc.), Machine Drive, and Waste Energy Recovery/CHP

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Machine Drives						
6	**Water - energy efficiency initiatives**	Added	market & technical	Need alignment of government plus water agencies, as well utilities and other intermediaries to drive initiatives. Public support or acceptance is vital.	No funding for water conservation Reduced water consumption --> reduced water pumping costs Rain-water diversion --> reduced energy for waste water treatment	Link with water utilities, agricultural industry and education organizations (WSU, for one) Study end-users to understand underlying needs and decision criteral
1	**Low cost residential heat recovery system (fans)**	◆◆	market & other	Most cost effective in cold climates, so Canada and Scandinavia have been active in this technology since the 1980s. New heat exchanger designs may expand U.S. market penetration in 3 - 5 years. U.S. Homes don't have central exhaust --> cost prohib??? to recover heat	Not cost effective --> in NW mild climate Indoor air quality --> air exchange requirements Need significant increase in fuel cost lower exchanger	Issue of homes being too tight --> air quality
2	**Low-cost, variable speed motors for small appliances**	◆◆	technical & market	In market- need further development of products for a broad range of applications at reduced cost.	Major motor suppliers have commercially available - ECM (Electronically Commutated Motors) Energy Star --> recognize high efficiency products	Utility incentive programs to encourage adoption of ultra-high efficiency appliances --> beyond Energy Star
3	**Adjustable speed drives for small ~~power movers~~ motors**				Market available ASD --> at sub 1 hp Utility incentive programs available for incentives (but flat rate on size - don't look at controls)	Pilot studies??? Issue is ???? Time --> to set up design and install control loop, (not a capital cost issue) --> need control tech??? Vs. electrical hook up Need more simplified pre-set controls Application specific --> R&D to target applications develop custom controllers

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Other (Industrial, Agricultural, etc.), Machine Drive, and Waste Energy Recovery/CHP

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
Waste Energy Recovery and CHP						
1	**Waste energy recovery**	◆◆	technical & market	Need expanded development of products, support infrastructure for design, installation, and maintenance; market pull by potential customers segments.	Some new equipment be developed Lack system integration funding --> gas and electric	Need training and close application Research and user communication Demonstration project funding Cost effective thermal recovery system Identify sources of waste heat BPA fund pilot projects/market potential research
1.1	**Water, sewage**		other	Need financial drivers for water & wastewater utilities, market pull and government advocacy. Very slow industry to adopt change	Same utility incentives limited targeted programs	Specialized industry Municipal --> slow to change Low cost bid market Energy Management Focus on organizational management change
2	**CHP**	◆	other & technical	Barriers include emission impacts and lack of robust maintenance infrastructure. Utility dis-incentive to not encourage customers to generate their own power Regulations prevent CHP generators from selling power to compete with utilities	Many complex regulatory and market issues --> DOE been working this for 30+ years	BPA --> should fund demonstration projects, incentives for utilities to encourage CHP installations
	Improved Human Interface Control		Added	Many proprietary systems complex interface temptation to "by-pass" automation Lack of ease of use		Good user interface is hard Need research into human interface--> need intuitive, user friendly, persistence (example iPod vs. MP3

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NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Regulation

	Existing Product & Servce Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
1	**Code compliance**	◆◆	other	Need alignment of government plus utilities and/or NGOs to drive initiatives. Public support or acceptance is vital. California is active in this domain.		
1.1	**Education**		other	Need engagement of government plus NGOs and/or utilities to drive initiatives. Public support or acceptance is vital.		
1.2	**Workforce**		other	(Not sure what this refers to - perhaps the need to expand the code-compliance workforce?)		
2	**Time of sale EE upgrade requirement**	◆◆	market & other	Exists on a pilot basis in some jurisdictions such as Burlington, VT. Need engagement of government and real estate industry to drive initiatives. Public support or acceptance is vital.		
3	**Performance based energy codes**	◆	other	Need alignment of government plus building industry, plus utilities and/or NGOs to drive initiatives. Public support or acceptance is vital. California is active in this domain.		
4	**Rate design for ancillary services**		other & market	Exists on a pilot basis for some services. Need utility, regulatory, customer engagement to achieve market penetration. Energy efficiency has not been the primary driver of this service in the past.		

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Appendix A5:
Workshop 4 (Prioritization) (Feb. 5, 2010)

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Agenda

Northwest Energy Efficiency Technology Roadmap Workshop #4
—Prioritization—
February 5, 2010

Location: Room 1A, OR State Building, 800 NE Oregon St., Portland 97232 (Adjacent to BPA HQ)

Purpose of Workshop Series:

- To develop the framework for identifying, selecting, and prioritizing high-value, energy efficiency (EE) research, development, and commercialization to be pursued by Northwest organizations and agencies

Purpose of Workshop #4:

- Prioritize needed R&D programs
- Prioritize products and services currently available in the marketplace but not widely adopted

Friday, February 5, 2010

9:00 am — Welcome, Review, Description of Goals and Process for Workshop 4

- **Joshua Binus**, *Bonneville Power Administration*

9:30 am — Scoring of Product/Service Areas and Criteria

9:45 am to 1:00 pm — Scoring of R&D program gaps

Score by Product/Service Area:

9:45	Building Design/Envelope for Retrofit
	Building Design/Envelope for New Construction
10:35	**Break**
10:45	Lighting
11:15	Electronics
11:45	**Lunch delivered**
12:00	Heating, Ventilation, and Air Conditioning
12:30	Sensors, Meters, and Energy Management Systems

1:00 pm — Break

1:00 am to 4:00 pm — Scoring of Available Products/Services

Score by Product/Service Area:

1:00	Building Design and Performance; Building Envelope
1:30	Water Heating and HVAC
2:00	Lighting, Appliances, and Electronics
2:30	**Break**
3:00	EMS; Sensors and Meters
3:30	Machine Drive, Waste Energy Recovery/CHP, Other

4:00 pm — Closing Comments and Next Steps

4:30 pm — Adjourn

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Evaluation Form

Prioritizing Product & Service Areas (1/2)

- R&D Programs

Product and Service Area	**Score (1-5)**
A1: Building Design/Envelope for Retrofit (Retro)	
A2: Building Design/Envelope for New Construction (NC)	
A3: Lighting	
A4: Electronics	
A5: Heating, Ventilation, and Air Conditioning (HVAC)	
A6: Sensors, Meters, and Energy Management Systems	

Evaluation Form

Prioritizing Product & Service Areas (2/2)

- Products not widely adopted

Product and Service Area	**Score (1-5)**
A1: Building Design, Performance, Envelope, and AARA	
A2: Water Heating and HVAC	
A3: Lighting, Appliances, and Electronics	
A4: Machine Drive, Waste Energy, Recovery/CHP, and Other (Industrial, Agricultural, etc.)	
A5: Sensors, Meters, and Energy Management Systems	

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Evaluation Form

Prioritizing the Criteria

Criteria of R&D programs	Score (1-5)
C1: Potential energy efficiency savings for NW	
C2: Potential non-energy benefits / consumer value	
C3: Ability of NW to contribute to the development	
C4: Research focus uniquely applicable to NW	

Criteria of Products not widely adopted	Score (1-5)
C1: Potential energy efficiency savings for NW	
C2: Potential non-energy benefits / consumer value	
C3: Ability of NW to affect market	
C4: Readiness of widespread adoption	

Prioritization STEP 3-1

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP IV
Prioritization of the Technology and R&D Programs
February 5, 2010

Evaluation Form

	Product & Service Area: A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)				
Product & Service Group	**R&D Program**	**C1: Potential energy efficiency savings for NW**	**C2: Potential non-energy benefits / consumer value**	**C3: Ability of NW to contribute to the development**	**C4: Research focus uniquely applicable to NW**
Deep Retrofits for Residential & Commercial	RD1. Categorize building stock for better, easier testing				
Deep Retrofits for Residential & Commercial	RD2. R&D for TC4. Mixed use: use heat from commercial for residential, integrate markets				
Retro and NC Windows	RD1. What is there beyond fiberglass – highly insulated, lightweight				
Retro and NC Windows	RD2. R&D for TC1. Next-gen coatings for triple-glazed IGs with superior SHGC and U-factor ratings				
Retro and NC Windows	RD3. R&D for TC2. Integral low-E and PV windows				
Retro and NC Windows	RD4. R&D for TC3. Self-powered electrochromic-PV windows				
Retro and NC Windows	RD5. R&D for TC4. Glazing, vacuum filled 1-pane, low-e windows				
Retro and NC Windows	RD6. R&D for TC7. Heavily insulated electrochromic windows				
Transformative Building Materials	RD1. R&D for TC5. Insulating sheetrock alternative				
Transformative Building Materials	RD2. R&D for TC6. Insulated building exterior material				
Solar / Smart Roofing	RD1. R&D for TC2. Cool / PV / DHW heater roofing				
Solar / Smart Roofing	RD2. R&D for TC3. Solar survey mobile application for residential (exists for commercial)				
Solar / Smart Roofing	RD3. R&D for TC5. Solar shingles				
Retrofit Insulation	RD1. “Smart” material that fills all cavities, mistake-free and inexpensive				
Retrofit Insulation	RD2. R&D for TC2. Community aerial IR scan + GPS data systems				
Retrofit Insulation	RD3. R&D for TC6. Device that scans IR and calculates heat load				

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Prioritization STEP 3-1

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP IV
Prioritization of the Technology and R&D Programs
February 5, 2010

Evaluation Form

	Product & Service Area: A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)				
Product & Service Group	**R&D Program**	**C1: Potential energy efficiency savings for NW**	**C2: Potential non-energy benefits / consumer value**	**C3: Ability of NW to contribute to the development**	**C4: Research focus uniquely applicable to NW**
Net Zero Energy Home	RD3. R&D for TC2. Low power, DC wired homes – reduce conversion losses, buildings built for no respect to dissimilar loads and zones and no stock assessment				
Net Zero Energy Home	RD4. R&D for TC6.Smarter electrical plugs, programmable, addressable (in development)				
Retro & NC Air Sealing	RD1. Research to move air sealing to prescriptive and into hands of QC and out of contractors				
Retro & NC Air Sealing	RD2. Application technology that is easy and cheap, even a caveman can do it				
New Construction Insulation	RD1. Application technology, “easy and cheap”				
Day Lighting Walls	RD2. R&D for TC1. Easier, cheaper daylight modeling tools that give energy benefits				
Manufactured	RD1.Shop floor innovative technologies similar to auto industry				
IR Scanning	RD1.Marry the energy technology with smart phone/device technology				

Prioritization STEP 3-1

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP IV
Prioritization of the Technology and R&D Programs
February 5, 2010

Evaluation Form

Product & Service Area: A3. LIGHTING

Product & Service Group	R&D Program	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to contribute to the development	C4: Research focus uniquely applicable to NW
Lighting	RD3.Self-cleaning luminaries				
Lighting	RD4. Red LED integrated into FCL for improved CRI				
Lighting	RD5. R&D for TC2. Luminaire optics for plasma light				
SSL	RD1.Electric system compatibility				
SSL	RD8. Thermoelectronic heat recovery from LEDs				
Improve Task/Ambient Application	RD1. Human factor- usability and comfort				
Improve Task/Ambient Application	RD2. Hospital lighting systems				
Lighting Controls (Dimming, OC Sensors	RD1. Predictive modeling for dynamic lighting needs				
Lighting Controls (Dimming, OC Sensors	RD3. R&D for TC7. Cheaper, more simple self calibration				
Day Lighting	RD6. R&D for TC2. Cheaper and more simple self calibrating dimming controls				
Day Lighting	RD7. R&D for TC4. Skylight design				

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Prioritization STEP 3-1

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP IV
Prioritization of the Technology and R&D Programs
February 5, 2010

Evaluation Form

	Product & Service Area: A4. ELECTRONICS				
Product & Service Group	R&D Program	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to contribute to the development	C4: Research focus uniquely applicable to NW
Sleep Mode	RD1. Optimize user interface				
Sleep Mode	RD3. Behavior economics for how people use devices				
Sleep Mode	RD5. Accessible and simple interface controls				
Sleep Mode	RD7. Software compatibility with stand-by modes				
Sleep Mode	RD8. R&D for TC4. Sleep mode more responsive to late night network admin. Updated				
Sleep Mode	RD9. R&D for TC5. Video games with sleep mode are also losing score				
DC Power Source	RD2. DC safety				
DC Power Source	RD3. Explore DC appliances with speed control				
DC Power Source	RD4. DC loss reduction				
DC Power Source	RD5. Power line carrier for DC lines				
DC Power Source	RD7. How much “stuff” in home is DC? AC?				
DC Power Source	RD9. UPS – PV integration (large or small)				
Use and Virtualization	RD3. Ergonomic research on right sized TV & computer display				
Use and Virtualization	RD4. Visual performance impacts with micro-screens				
Use and Virtualization	RD6. Information synopsis				
Use and Virtualization	RD10. Improving information management				
Component Level Efficiency	RD1. Integrated solutions for device component on/off state				
Complete Electronic System	RD2. Broad research on system – level efficiency opportunities in electronics				
Interlock Devices to Manage Energy Use	RD2. Behavioral issues/opportunities for next generation of “smart homes”				

Prioritization STEP 3-1

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP IV
Prioritization of the Technology and R&D Programs
February 5, 2010

Evaluation Form

Product & Service Area: A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)					
Product & Service Group	**R&D Program**	**C1: Potential energy efficiency savings for NW**	**C2: Potential non-energy benefits / consumer value**	**C3: Ability of NW to contribute to the development**	**C4: Research focus uniquely applicable to NW**
Low-carbon, sustainable, high-efficiency products and systems that automatically diagnose, predict, and maintain high efficiency throughout the product life cycle without sacrificing amenity or service delivery	RD1. (GL14) Heat recovery optimization routines such that economizer are not impacted				
	RD2. (GL14) No current MTBF testing, case (Title 24 goal for 2013)				
	RD4. Some research on neural reps etc. not conclusive – need more algorithm development				
	RD7. (TC4) Make ECM motors bigger and do belt drive				
	RD9. Drop-in ECM motors for residential, need furnaces, case studies, savings, etc.				
	RD14. Fault response on compressor related to US companies				
	RD16. (TC13) VRF, more information about energy use, improving controls				
	RD17. (TC4) Better mini-split controls VRF				
	RD18. (TC12) Water-based VRF systems to incorporate geothermal with VRF				

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Evaluation Form

Product & Service Area: A6. SENSORS, METERS, ENERGY MANAGEMENT SYSTEMS

Product & Service Group	R&D Program	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to contribute to the development	C4: Research focus uniquely applicable to NW
Smart device – level controls responsive to user and environment	RD1. (GP2, GP5) Scan existing ubiquitous technology from cell phones for transformation to new use in this application				
Easy/simple user interface controls	RD1. Study of what energy management devices do people actually use?				

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Building Design and Performance

Product & Service Area: A1. Building Design, Performance, Envelope, and AARA

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Deep retrofits – commercial, residential Whole house, whole building	Programs to amortize cost: EE loans (low interest) Interest buy-down programs Connection or rate advantages				
Community master planning	Holistic approach with all players Legal barriers to shared systems (creating mini utilities) Cross discipline education				
Integrated building design (= advanced efficiency and productivity and understanding 1st cost) (commercial) (N)	Design/availability of user-friendly modeling tools Formal education programs (colleges) Cross-disciplinary education at the right time - use professional associations				

Building Envelope

Product & Service Area: A1. Building Design, Performance, Envelope, and AARA

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
High efficiency windows – more than double pane	Bring cost down - prove longevity Aesthetics and potential increased resale value Codes Market transformation Bundle with other measures				
Advanced roofing materials - Reflect PV and Green Roofs	Demonstrate/identify benefit to end user Standardized installation practices and education for bundle with deep retrofits to gain cost-effective roofing contractors				
Residential shell upgrades (more products/systems) – easy/cheap?	Trade education/training Cost amortization, see #1 (deep retrofits) No big manufacturers No quality control				

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AARA — **Product & Service Area: A1. Building Design, Performance, Envelope, and AARA**

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Infrared scanning services	Could be an inspection tool Equipment loaner program Integrate with programs to get cost-effective savings Certification of technicians Whole neighborhood				
Foam wall insulation	Aesthetics Cost/environmental impact must be improved Integration into other structural materials				
Non-utility weatherization funding	Track savings (system) Engagement between utilities with community groups, government programs and developers				
Cost-effective residential air sealing - retrofits and M&V	Whole neighborhood/targeted homes to decrease wind shift time tie into programmatic savings Targeted approach based on housing stock				
Effective insulated window shades					

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Water Heating — **Product & Service Area: A2. Water Heating and HVAC**

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Heat pump water heaters with exhaust vent Mini split with space and water heat	Testing United specification - Northern Tier Customer feedback application guidance Supply chain strategy Training				
Solar DHW for commercial / residential applications	Integrated system Mass market contractor business model Cost reduction Product improvements - plastic? Volvmet Price Target high C/I users Solar ready construction?				

HVAC (1/2) — **Product & Service Area: A2. Water Heating and HVAC**

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Commercial variable refrigeration flow Please compact heating recovery multiple for coils. Quiet integrated controls create building ???? System. Offer using EMS to calculate rough submetering costs based on fan coil operating.	Find out savings Build into established models See if further utility role needed Installation QC training.				
Geothermal heat pump for residential and commercial use	Res. Focus on cold climate CFI - training get A&E's familiar with hydrogen-experts. Also drillers. Trade ally/cert.				

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Prioritization STEP 3-2

Evaluation Form

HVAC (2/2)

Product & Service Area: A2. Water Heating and HVAC					
Product & Service Group	**Core Component of Future Programs and Initiatives**	**C1: Potential energy efficiency savings for NW**	**C2: Potential non-energy benefits / consumer value**	**C3: Ability of NW to affect market**	**C4: Readiness of widespread adoption**
Non-vapor compression cooling systems (50%<)	Demonstrations/field test Communicate interest and support needs to manufacturers and distribute Follow success elsewhere.				
Low temperature air source heat pumps	Is this a priority Focus on low temp ductless minis?				
In-floor heating/cooling (electrically driven) – with fluid Plus water loop saves space	Is this an electric issue? Future = gas wall hung boiler R demos where electric now homes exist C radiant in 60-70 past code-panels Opportunities to drive down equipment and system cost - but is that our job?				
Demand-controlled ventilation for commercial kitchen stove hoods	Understand product differences and savings National level issue Field tests, modeling, spending more time at engineering level understanding Get a bunch on Strong multilevel restaurant marketing programs Work on no AC home				
Inverter Driven res whole house heating pump	Basic scoping cost analysis for MT field test				
Swamp cooler or cooler (?)					
Minis print Res space and water heat	Explanation field test				
Whole house in p w S&W heat	H couple field test				

Prioritization STEP 3-2

Evaluation Form

Lighting

Product & Service Area: A3. Lighting, Appliances, and Electronics					
Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Solid state lights	Incentives for street lights/deemed savings Avoid bad products/black eye Signage on grocery LEDs Consumer incentives to offset cost (resdiential) distribution and availability get beyond niche Benchmarking and product recommendations for streetlighting (right product, right application) Program: solid-state "training wheels" e.g., holiday lights to create halo into new product Cross the chasm - word of mouth/referral approach to build awareness and build demand Affinity grasps built around early adopters Awareness - bulding of benefits				
Efficient metal halide fluorescent fixtures	Turn off lights and plug load at night, leaving Couch potato ease - no messy wires Enabling technology				

Appliances

Product & Service Area: A3. Lighting, Appliances, and Electronics					
Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Wireless homes					
(Ultra Efficient) Car Chargers	Upstream influence Policy (standards) Manufacturers, e.g., keep inefficient charges from hitting market Certification program (e.g., Energy Star) Upstream to mfg and pucles ALA NEEA/ECOs 80 Energy Star certification Upstream intervention - avoid introduction of low-efficient chargers Policy/standards/lobbying				

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Electronics (1/2)

Product & Service Area: A3. Lighting, Appliances, and Electronics

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Data centers	Utility and corp and consultant training Deemed savings for virtualization and power conversion More resources on design, rather than optimization LBNL resources ASHRAE training Awareness outreach to target audience Commodity market - tough business case Case studies from demonstrations Create target data center program IT, peer to peer interaction				
Virtualization and consolidation of small system					
HVAC					
Power conversion					
Environmental interlocks – hotel key locks	Expand past hotel to office, home, etc. Address hotel management concern of risks benefits Linking office occ. Sens. To HVAC smart strips Pilots to gather data - quantify Cost/benefit Qualitative Guest acceptance				
Smart strips – turn off appliances when not being used	Utility incentives for smart strips ~$15/per Awareness effort . . . Phantom load the true cost of your gadgets Direct install? "How to" for end users - education to optimize use Survey plug load in power strips				

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Electronics (2/2)

Product & Service Area: A3. Lighting, Appliances, and Electronics

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Alarms/buzzers "indicators" when meet energy use threshold	Integrate alarms/buzzers with other behavior elements, like: O-Power (positive energy) Hohm/power meter Scorecard				
Alt: pre-paid metering	Utility cash flow less risk Good for low income transient - no down payment Utility offering and infrastructure (billing, charging cards, kiosks, monitoring devices)				
Cradle to grave design	Total cost of ownership as credible decision influence (sales tools, point-of-purchase, etc.)				
Sustainability					
Efficient home electronics	X-Box = 200W = 3/4 Fridge WILL = 20 watts				
Sleep Mode					
Day lighting	Promote productivity increases, tie to bottom line				

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Evaluation Form

Other (Industrial, Agricultural, etc.)

Product & Service Area: A4. Machine Drive, Waste Energy, Recovery/CHP, and Other (Industrial, Agricultural, etc.)

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Industrial large commercial voltage/electric system optimize	Field testing --> on long term impact on industrial systems and motors subject water training --> utilities and industrial users Case studies on proven results Demonstrate no operations impact				
Consumer education – certification What is this? Not enough information	Need M&V standards to evaluate performance				
Low pressure pump irrigation (Agriculture), existing but not sufficient					
Low air-flow laboratory fume hoods or Smart noods (?)--> close sash when not in use	Set up M&V standard Case studies, demonstration projects Need incentives, installation support specific Target Market Segment				
Quality assurance and commissioning	Installation verification Issue of how to evaluate "appropriate for use" Feedback --> vendor performance program				

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Machine Drives | **Product & Service Area:** A4. Machine Drive, Waste Energy, Recovery/CHP, and Other (Industrial, Agricultural, etc.)

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Water - energy efficiency initiatives					
Low cost residential heat recovery system (fans)	Issue of homes being too tight --> air quality				
Low-cost, variable speed motors for small appliances	Utility incentive programs to encourage adoption of ultra-high efficiency appliances --> beyond Energy Star				
Adjustable speed drives for small power movers motors	Pilot studies (?) Issue is (?) Time --> to set up design and install control loop, (not a capital cost issue) --> need control tech(?) Vs. electrical hook up Need more simplified pre-set controls Application specific --> R&D to target applications develop custom controllers				

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Waste Energy Recovery and CHP

Product & Service Area: **A4. Machine Drive, Waste Energy, Recovery/CHP, and Other (Industrial, Agricultural, etc.)**

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Waste energy recovery	Need training and close application Research and user communication Demonstration project funding Cost effective thermal recovery system Identify sources of waste heat BPA fund pilot projects/market potential research				
Water, sewage	Specialized industry Municipal --> slow to change Low cost bid market Energy Management Focus on organizational management change				
CHP	BPA --> should fund demonstration projects, incentives for utilities to encourage CHP installations				
Improved Human Interface Control	Good user interface is hard Need research into human interface--> need intuitive, user friendly, persistence (example iPod vs. MP3				

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EMS

Product & Service Area: A5. Sensors, Meters, and Energy Management Systems

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Low-cost EE savings verification techniques	Enhance Hohm, Google Power Meter to incorporate these capabilities Make these approaches part of utility programs, available to consultants Leverage often in-home service like TV, home theater, misc., electrical work.				
Easy/simple consumer (user) controls	Need long-term engagement from residential and small commercial customers Need value preposition for end-use customers and service partners Need utility incentives				
Consumer energy management service(s)	Need residential service providers (all are ??? Now) Educate service providers on value preposition Find families "Neilson families") who are ok with continuous monitoring projects at their homes - as test bed for range of EE products				
Industrial energy optimization	2011: ISO S1000 will establish highest level for industrial energy management Now to 2015: need simpler tools deployable for small/medium industrial segments				

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Sensors and Meters (1/2)

Product & Service Area: A5. Sensors, Meters, and Energy Management Systems

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
EMS that can interact with the Smart Grid	Need value preposition for utilities and consumers ADR - empowers utility for DR Need to link EMS to real time and historic consumer usage data Leverage free devices/services from DR companies --> roll out EE service piggy backed on DR				
Smart device level controls responsive to user and environment	Import solutions from Japan, China Build proximity sensors into TVs to sense if anyone is in room turn off screen if not (manufacturers - Sharp, others) Incentives for controls built into OEM products				
Air quality sensors control ventilation	Incent big players like Trane, Carrier to build these sensors into HVAC system to drive broad deployment				
Inexpensive end-use load monitoring	Need utility value proposition to drive future program This may be non-energy driven like safety, security				
Real time consumption by appliance	Need re(?) On how to (?) Customers with information Incentive/encourage appliance manufacturers to link monitoring to direct control capabilities Explore trade-offs: smart outlets vs smart appliances - which costs less? Develop better "smart" control algorithms and software				
New commercial building electric metering, measurement protocols, and benchmarks	Incent software for smart meters to do benchmarking, EM&V Need lower cost solutions Link to continuous commissioning				

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Sensors and Meters (2/2)

Product & Service Area: A5. Sensors, Meters, and Energy Management Systems

Product & Service Group	Core Component of Future Programs and Initiatives	C1: Potential energy efficiency savings for NW	C2: Potential non-energy benefits / consumer value	C3: Ability of NW to affect market	C4: Readiness of widespread adoption
Residential occupancy sensors	Cost reduction strategies - installation by electricians drives cost - so combine with other in-home service - see EMS Item #1 Also incent installs as part of comprehensive retrofit or any light?? Install Look at other ways to adapt commercial programs for residential				
Smart utility meters for all customers	What's the value preposition for the majority of utilities?				
Smart charging recharging	Link in-home EMS/metering products with charging capabilities Establish costs and value proposition Chicken-egg problem (split incentives) Which comes first - vehicles or infrastructure?" What will drive utility equipment installations?				

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R&D Programs

70< | 70≤ | 80≤ | 90≤

Product & Service Area	Product & Service	R&D Program	Without any weight Scores (Max=100	Rank	Criteria Weighted Scores (Max=100)	Rank	Area-Criteria Weighted Scores (Max=100)	Rank
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD17. (TC4) Better mini-split controls VRF	97	2	100	1	100	1
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD1. (GL14) Heat recovery optimization routines such that economizer are not impacted	95	3	98	2	98	2
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Retro & NC Air Sealing	RD1. Research to move air sealing to prescriptive and into hands of QC and out of contractors	87	7	97	3	97	3
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Manufactured	RD1.Shop floor innovative technologies similar to auto industry	85	8	96	4	97	4
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Retro & NC Air Sealing	RD2. Application technology that is easy and cheap, even a caveman can do it	85	9	96	5	95	5
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Deep Retrofits for Residential & Commercial	RD1. Categorize building stock for better, easier testing	74	21	95	6	95	6
A3. LIGHTING	Improve Task/Ambient Application	RD1. Human factor- usability and comfort	100	1	94	7	95	7
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Net Zero Energy Home	RD4. R&D for TC6.Smarter electrical plugs, programmable, addressable (in development)	82	13	92	8	92	8
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD2. R&D for TC1. Next-gen coatings for triple-glazed IGs with superior SHGC and U-factor ratings	71	28	91	9	91	9
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Day Lighting Walls	RD2. R&D for TC1. Easier, cheaper daylight modeling tools that give energy benefits	80	15	90	11	91	10
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD16. (TC13) VRF, more information about energy use, improving controls	87	5	90	10	90	11
A6. SENSORS, METERS, ENERGY MANAGEMENT SYSTEMS	Easy/simple user interface controls	RD1. Study of what energy management devices do people actually use?	78	17	88	13	89	12
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	Net Zero Energy Home	RD3. R&D for TC2. Low power, DC wired homes – reduce conversion losses, buildings built for no respect to dissimilar loads and zones and no stock assessment	78	18	88	14	88	13
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retrofit Insulation	RD1. “Smart” material that fills all cavities, mistake-free and inexpensive	68	34	88	12	87	14
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD1. What is there beyond fiberglass – highly insulated, lightweight	66	39	85	15	84	15
A3. LIGHTING	Lighting Controls (Dimming, OC Sensors	RD3. R&D for TC7. Cheaper, more simple self calibration	89	4	84	16	84	16
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	New Construction Insulation	RD1. Application technology, “easy and cheap”	73	22	83	17	82	17
A4. ELECTRONICS	Sleep Mode	RD3. Behavior economics for how people use devices	75	20	82	18	82	18
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Transformative Building Materials	RD2. R&D for TC6. Insulated building exterior material	63	44	82	19	81	19
A3. LIGHTING	Day Lighting	RD6. R&D for TC2. Cheaper and more simple self calibrating dimming controls	87	6	81	21	81	20
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD18. (TC12) Water-based VRF systems to incorporate geothermal with VRF	79	16	81	20	80	21
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD3. R&D for TC2. Integral low-E and PV windows	63	45	81	22	80	22
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD4. R&D for TC3. Self-powered electrochromic-PV windows	62	46	81	23	80	23
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD6. R&D for TC7. Heavily insulated electrochromic windows	62	47	80	24	79	24
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retrofit Insulation	RD3. R&D for TC6. Device that scans IR and calculates heat load	61	48	79	25	79	25
A3. LIGHTING	Improve Task/Ambient Application	RD2. Hospital lighting systems	84	10	78	27	79	26
A4. ELECTRONICS	Interlock Devices to Manage Energy Use	RD2. Behavioral issues/opportunities for next generation of “smart homes”	73	26	79	26	78	27
A6. SENSORS, METERS, ENERGY MANAGEMENT SYSTEMS	Smart device – level controls responsive to user and environment	RD1. (GP2, GP5) Scan existing ubiquitous technology from cell phones for transformation to new use in this application	68	33	77	28	78	28
A3. LIGHTING	Day Lighting	RD7. R&D for TC4. Skylight design	82	11	77	29	78	29
A3. LIGHTING	Lighting Controls (Dimming, OC Sensors	RD1. Predictive modeling for dynamic lighting needs	82	12	77	30	77	30
A3. LIGHTING	Lighting	RD3.Self-cleaning luminaries	80	14	75	36	77	31
A4. ELECTRONICS	Sleep Mode	RD5. Accessible and simple interface controls	70	29	76	31	76	32
A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)	IR Scanning	RD1.Marry the energy technology with smart phone/device technology	66	38	74	38	76	33
A4. ELECTRONICS	Sleep Mode	RD7. Software compatibility with stand-by modes	70	30	76	32	75	34
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retro and NC Windows	RD5. R&D for TC4. Glazing, vacuum filled 1-pane, low-e windows	59	50	76	33	75	35
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Solar / Smart Roofing	RD1. R&D for TC2. Cool / PV / DHW heater roofing	57	52	74	39	74	36
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD9. Drop-in ECM motors for residential, need furnaces, case studies, savings, etc.	73	25	75	35	74	37
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD2. (GL14) No current MTBF testing, case (Title 24 goal for 2013)	71	27	73	41	74	38
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD7. (TC4) Make ECM motors bigger and do belt drive	73	23	75	34	73	39
A4. ELECTRONICS	Complete Electronic System	RD2. Broad research on system – level efficiency opportunities in electronics	69	32	74	37	73	40
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Retrofit Insulation	RD2. R&D for TC2. Community aerial IR scan + GPS data systems	57	55	73	40	73	41
A4. ELECTRONICS	Sleep Mode	RD1. Optimize user interface	67	35	73	42	73	42
A4. ELECTRONICS	Component Level Efficiency	RD1. Integrated solutions for device component on/off state	67	36	73	43	72	43
A3. LIGHTING	SSL	RD1.Electric system compatibility	78	19	73	44	72	44
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Solar / Smart Roofing	RD3. R&D for TC5. Solar shingles	55	59	72	46	72	45
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Transformative Building Materials	RD1. R&D for TC5. Insulating sheetrock alternative	56	56	72	45	71	46
A4. ELECTRONICS	Sleep Mode	RD9. R&D for TC5. Video games with sleep mode are also losing score	65	40	71	47	70	47
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Deep Retrofits for Residential & Commercial	RD2. R&D for TC4. Mixed use: use heat from commercial for residential, integrate markets	53	61	68	49	69	48
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD4. Some research on neural reps etc. not conclusive – need more algorithm development	66	37	68	51	69	49
A3. LIGHTING	Lighting	RD5. R&D for TC2. Luminaire optics for plasma light	73	24	68	50	69	50

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R&D Programs

70< 70≤ 80≤ 90≤

Product & Service Area	Product & Service	R&D Program	Without any weight Scores (Max=100	Rank	Criteria Weighted Scores (Max=100)	Rank	Area-Criteria Weighted Scores (Max=100)	Rank
A4. ELECTRONICS	Sleep Mode	RD8. R&D for TC4. Sleep mode more responsive to late night network admin. Updated	64	42	69	48	68	51
A3. LIGHTING	Lighting	RD4. Red LED integrated into FCL for improved CRI	70	31	65	54	67	52
A4. ELECTRONICS	Use and Virtualization	RD10. Improving information management	61	49	66	52	66	53
A5. HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)		RD14. Fault response on compressor related to US companies	64	43	66	53	66	54
A4. ELECTRONICS	DC Power Source	RD2. DC safety	57	51	62	55	64	55
A4. ELECTRONICS	Use and Virtualization	RD6. Information synopsis	57	53	62	56	62	56
A4. ELECTRONICS	DC Power Source	RD3. Explore DC appliances with speed control	57	54	62	57	61	57
A3. LIGHTING	SSL	RD8. Thermoelectronic heat recovery from LEDs	65	41	61	58	60	58
A4. ELECTRONICS	DC Power Source	RD9. UPS – PV integration (large or small)	56	57	61	59	60	59
A1. BUILDING DESIGN/ENVELOPE FOR RETROFIT (RETRO)	Solar / Smart Roofing	RD2. R&D for TC3. Solar survey mobile application for residential (exists for commercial)	46	65	60	61	60	60
A4. ELECTRONICS	DC Power Source	RD7. How much “stuff” in home is DC? AC?	56	58	61	60	59	61
A4. ELECTRONICS	Use and Virtualization	RD3. Ergonomic research on right sized TV & computer display	51	62	56	63	57	62
A4. ELECTRONICS	DC Power Source	RD4. DC loss reduction	54	60	59	62	56	63
A4. ELECTRONICS	Use and Virtualization	RD4. Visual performance impacts with micro-screens	51	63	55	64	56	64
A4. ELECTRONICS	DC Power Source	RD5. Power line carrier for DC lines	48	64	52	65	51	65

High Priority Products / Services Needing Wider Adoption

Product & Service Area: Building Design, Performance, and Envelope | Water Heating and HVAC | Lighting, Appliances, and Electronics

Driver

Environmental & Global Driver: 1. Climate change, 2. Peak oil, 3. Energy security, 4. Water scarcity and cost, related health concerns, 5. Increasing cost and decreasing availability of raw materials (i.e. wood, copper), 6. Environmental impact of centralized power generation, 7. Fuel switching from combustion to electric

Market Driver: 1. Increasing and uncertain future cost of electricity and gas, 2. Proliferation of consumer electronics (increased plug loads), 3. More and cheaper products due to globalization of manufacturing, 4. Increase in available funding for EE, 5. Increased adoption of LEED, 6. Changes in types of industries in the Northwest, 7. Market awareness (e.g., E3T and utility demos and outreach), 8. Increased interest in and availability of plug-in hybrid and electric vehicles, 9. Energy efficiency promoted through mainstream media

Behavior / Social Driver: 1. Employer pressure to increase productivity, 2. Consumer desire to be "green" and reduce embedded & used energy, 3. Consumer desire for comfort and aesthetics, 4. Changing demographics impacting purchasing choices and behavior, 5. Personal energy independence; interest in living off the grid, 6. Increased awareness of impact of behavior on energy usage, 7. Aging workforce, lack of trained workforce, 8. Pushback against over-regulation, 9. People like cool, new technologies, 10. People more "plugged in" electronically, digital information, social networking

Policy & Regulatory Driver: 1. Carbon emissions penalties and/or incentives, 2. Use of codes to lock in efficiency gains, 3. Increasing budgets for emerging technology R&D, 4. American Clean Energy and Security Act of 2009, 5. Integrated resource planning, 6. Increased interest among legislators in efficiency and renewable, 7. Limits to existing transmission and generation capacity, 8. Smart grid technology development

Technology Innovation Driver: 1. Moved to Social/Behavioral, 2. Diffusion of common communication protocols into energy-consuming devices, 3. Integration of info, communication & entertainment devices, 4. Moved to Environmental/Global, 5. Availability of new technologies such as solid state lighting, 6. Moved to Policy/Regulatory, 7. Availability of cross-cutting, low-cost technology building blocks (i.e. wireless, ultra compact heat exchangers, advanced controls, ASDs)

Product & Service

- Integrated building design (advanced efficiency and productivity and understanding 1st cost), [commercial]
- Commercial variable refrigeration flow. Compact heating recovery multiple for coils; Quiet integrated controls create building ???? System. Offer using EMS to calculate rough submetering costs based on fan coil operating.
- Heat pump water heaters with exhaust vent
- Mini split with space and water heat
- Demand-controlled ventilation for commercial kitchen stove hoods
- Minisplit print Res space and water heat
- Data centers
- Virtualization and consolidation of small system
- Environmental interlocks – hotel key locks
- HVAC
- Wireless homes
- Smart strips – turn off appliances when not being used
- Solid state lights
- Power conversion
- Efficient home electronics

Barrier

- Building America (U.S. DOE); Savings By Design (California IOUs). Need more user-friendly modeling tools and integration. Engineers, architects, buildings all have different needs/priorities
- Need increased market pull and availability, reduced cost; Need functional product from major manufacturer need proof of savings in our climate lab field consumer interaction price – space; Delivery - weight, complexity, contractor practices, training, buy-in service infrastructure
- Need technology improvement to reduce costs and ease of application, better documentation of energy savings; increased market pull; Established models don't model it yet.
- Need increased market pull and availability, reduced cost. Must be driven by local governments & industry to achieve broad acceptance.
- No standard kit; LOP implications unknown
- Need IT and data system specialists to align their activities with those of facility design, operation & management specialists.; Local small utilities lack credibility to advise; eplacement/retrofit costs - when used equipment is sunk cost
- Need better systems & system management applications to meet reliability and security requirements. Must be driven by client, industry, and government agencies' requirement to achieve broad acceptance.
- Need broad industry awareness of system performance and benefits to drive market pull.Customer acceptance (e.g., guest dissatisfaction. Retrofit costs to hotel quantification of benefit
- Need market pull by clients', industry, and government agencies' requirement to achieve broad acceptance.
- Needs technology development, market pull by consumers, builders, and appliance manufacturers. Awareness of benefits
- Need improved system performance & integration into home & office hardware. Must be driven by customers', commercial facilities' and government agencies' requirement to achieve broad acceptance.; Quantify savings; Not enough load on plug other than DVR and games; Distribution and availability; Verifying savings
- Primary technical & market barriers are reflected in Haitz' Law - lamp performance improving 30X and cost decreasing 10X every ten years.
- Need improved subsystems & integration into products. Must be driven by customers', retailers' and government agencies' requirement to achieve broad implementation.; Useful life of existing in-home electronics; Awareness (consumer) of energy impact of devices; Manufacturer incentive to integrate energy - use considerations in design
- (Not defined) 96
- (Not defined) 85
- (Not defined) 74
- (Not defined) 73

Core Component

- Design/availability of user-friendly modeling tools; Formal education programs (colleges); Cross-disciplinary education at the right time - use professional associations 75
- Application guidance Supply chain strategy Training 87
- Explanation field test 78
- Testing United specification - Northern Tier Customer feedback 90
- Find out savings; Build into established models; See if further utility role needed; Installation QC training 83
- Understand product differences and savings; National level issue; Field tests, modeling, spending more time at engineering level understanding; Get a bunch on; Strong multilevel restaurant marketing programs; Work on no AC home 74
- Expand past hotel to office, home, etc.; Address hotel management concern of risks benefits; Linking office occ. Sens. To HVAC smart strips; Pilots to gather data – quantify; Cost/benefit; Qualitative; Guest acceptance 75
- Utility and corp and consultant training; Deemed savings for virtualization and power conversion; More resources on design, rather than optimization; LBNL resources ASHRAE training;l Awareness outreach to target audience; Commodity market - tough business case; Case studies from demonstrations; Create target data center program; IT, peer to peer interaction 100
- Utility incentives for smart strips ~$15/per; Awareness effort . . . Phantom load the true cost of your gadgets; Direct install?; "How to" for end users - education to optimize use; Survey plug load in power strips 72
- X-Box = 200W = 3/4 Fridge WILL = 20 watts 76
- Incentives for street lights/deemed savings; Avoid bad products/black eye; Signage on grocery LEDs; Consumer incentives to offset cost (resdiential) distribution and availability get beyond niche; Benchmarking and product recommendations for streetlighting (right product, right application); Program: solid-state "training wheels" e.g., holiday lights to create halo into new product; Cross the chasm - word of mouth/referral approach to build awareness and build demand; Affinity grasps built around early adopters; Awareness - bulding of benefits 95

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Legend: Driver | Product and Service | Market Barrier for Adopting a product & Service | Core Component of Future Programs and Initiatives | # **Priority Ranking** (1 to 15)

Appendix A6:
Industrial Food Processing Workshop (Aug. 18, 2011)

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Agenda

NW Ind. Food Processing EE Technology Roadmap
Aug. 18, 2011

Purpose of Workshop: Provide technology experts engaged in the food processing industry with a structured workshop intended to produce info needed for the drafting of a "living" research agenda that identifies and prioritizes high-value, energy efficiency research and development topics for pursuit by pertinent Northwest stakeholders.

Thursday, Aug. 18, 2011

8:00 am — Welcome and Overview of Workshop Goals and Process

- **Joshua Binus**, *Bonneville Power Administration*

8:30 am — Task 1: Revise and Identify Drivers/Challenges

FOCUS QUESTION #1: Given the status of energy efficiency in the Northwest, and what has driven our activities to date, what drivers are expected to impact EE products and services in the next 20 years within food the processing industry?

9:15 am — Task 2: Identify & Negotiate Energy Efficiency Technology Categories

- Roadmaps will be developed for each of these categories
- Divide into sub-groups

9:45 am — Break

10:00 am — Task 3: Identify Capability Gaps Needed to Address Drivers

- Make sure to link Capability Gaps to appropriate Drivers

FOCUS QUESTION #2: What are the required capabilities (products and services) needed in order to address the identified drivers?

11:30 am — Working Lunch – Finish Identifying Capability Gaps (If completed, begin working on next task.)

12:00 pm — Task 4: Identify Technologies Needed to Address Capability Gaps

- Make sure to link Technologies to Capability Gaps
- Articulate whether each technology is "Commercially Available" or "Not Commercially Available"

FOCUS QUESTION #3:
What are the technological solutions which can be applied to enable currently unavailable capabilities needed over the next 20 years?

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1:30 pm	Task 5: Identify Existing R&D Programs; Identify R&D Gaps ► Make sure to link R&D Programs/Gaps to specific Technology(ies) Needed
	FOCUS QUESTIONS #4 and #5: What/where are the existing R&D programs which are addressing the technology gaps discovered in Question #3. What new R&D programs are needed to address technology gaps?
2:15 pm	Break
2:30 pm	Sub-Group Presentations & Group Discussion (Cross Fertilization)
4:30 pm	Review Process for Prioritization of R&D Programs [Post-Workshop]
5:00 pm	Adjourn

Industrial Food Processing Energy Efficiency Roadmap Workshop

DRAFT Minutes from Subgroup Presentations & Discussions
Aug. 18, 2011

Attendees:

1. Pam Barrow, Northwest Food Processors Association
2. Joshua Binus, BPA
3. Corey Corbett, Puget Sound Energy
4. Mike Eagen, Trident Seafoods
5. Jennifer Eskil, BPA
6. Mike Henderson, ConAgra Foods
7. Gray Johnson, Oregon Freeze Dry, Inc.
8. Pete Lepschat, Henningsen Cold Storage Co.
9. Qingyue Ling, Oregon State University
10. John Marshall, Northwest Food Processors Association
11. Graham Parker, PNNL
12. Mike Penner, Oregon State University
13. Rob Penny, WSU Extension Energy Program
14. Jim Peterson, Cold Solutions, LLC
15. Mark Rehley, Northwest Energy Efficiency Alliance
16. Steven Scott, MetaResource Group
17. Mark Steele, NORPAC Foods, Inc.
18. Don Sturtevant, J.R. Simplot, Co.
19. Juming Tang, Washington State University
20. Judy Thoet, Washington Association of Wine Grape Growers
21. Randy Thorn, Idaho Power
22. John Thornton, Northwest Food Processors Association
23. Geoff Wickes, Northwest Energy Efficiency Alliance
24. Marcus Wilcox, Cascade Energy, Inc.
25. Bill Wilson, WSU Extension Energy Program

JOSHUA BINUS: What I'm going to do is ask the presenters to start with the R&D program at the bottom and walk through what R&D programs your sub group got to that you're identifying a need to have attracting proposals essentially and then walk us back all the way up for each program what's the program need, what technology needs to be developed and what capability gap is that filling. You don't need to get up into the drivers, we've got those captures, but at least up through the capability gap for each R&D program.

Thermal:

MIKE HENDERSON: Each person that wrote R&D need will come up and explain that. I have one. It's develop proof of concept of a binary fluid injector the final development in commercialization. It's a tech I've has been made aware of, so has

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Bill Wilson, that might have potential. The stated idea grabber is that for 20% of the input gas energy it will accomplish the same as a 100% of heating hot water effect by thermally driving a heat pump price process. Obviously it needs a low temp sink and produces hot water and is applicable to other aspects in a processing plant which is the reason for our interest.

JOSHUA BINUS: With the ones that are commercially available, focus on the technical barriers, so that should be the R&D programs.

MIKE HENDERSON: I can't find the one it came from. I'm looking for Cut7. Binary fluid injector heat pump thermally driven and I gotta find CG 10. There's technology taking advantage of pricing during energy surplus periods. That's not right. How about CG9 on the right side? Equipment to upgrade heat content if way steams to higher more useful temperature ranges. That is exactly right. CG10. And it refers to MD 10.

JOSHUA BINUS: Let me ask before you go on, is it helpful for folks to actually hear the capability gaps in the report out or are you most interested in the R&D programming technology?

GROUP: The latter.

MIKE HENDERSON: Next, whoever did this one. JT.

JUMING TANG (JIMMY TAM): My name is Jimmy Tam from Washington State University. I've been working on the future technology and about 15 years ago supported by the US Army and DOD. This is a game changing technology that you talk about 20 years down the road. Hopefully a lot of companies are going to use it. The challenge has been to get FDA approval, give a lot of protocols. And we've got money to do that. What we've proven is we can actually shorten processing time by about 80 % comparing to conventional retorting. So we are using electric powered microwave so we can change the few steam to electricity. Now the common questions that I get from our consortium members, we form a platform which is called Consortium DOD. We have General Mills, we have Kraft, we have all those big companies, Pepsi and Nestle and Ocean Beauty Sea Food and Seattle. We already demonstrated Mike Krugers safety. Two FDA approvals. This is very unusual in the food industry to get FDA approval on new technology. Probably in the last 20 to 30 years, maybe one or two new technologies. So we are getting there, but in terms of energy efficiency, we don't have an answer for that. This is a very good platform and we're excited to be part of this and we do need to partnership with some people with energy efficiency expertise to work on this so that we have the information for the companies about energy efficiency. So that's kind of the research needs. And where it can be done is at Washington State University extension office and us and maybe some companies

JOSHUA BINUS: I want to clarify, that's where it *could* be done?

JUMING TANG (JIMMY TAM): Yes

JOSHUA BINUS: Not where it *is* being done?

JUMING TANG (JIMMY TAM): It has been done in the past at Washington State. We did that. Yes. With a lot of companies.

JOSHUA BINUS: Ok. Currently there's not an energy efficiency research under way at WSU?

JUMING TANG (JIMMY TAM): No. That's why it's in the yellow box.

MIKE HENDERSON: QL?

JUMING TANG (JIMMY TAM): QL is Ling and he has to give apology that he has another meeting. It is related to radio frequency heating, I believe. And also, it is kind of 20 to 50 years ahead. He has been doing that over the last 5 years. I don't know exactly what he put in there

MIKE HENDERSON: It says universal oven.

JUMING TANG (JIMMY TAM): Yes

MIKE HENDERSON: What is that?

JUMING TANG (JIMMY TAM): He was thinking about combining different heating methods including radio frequency which is the high penetration and heating methods compared to microwave penetration several times over. So more energy efficient way of cooking big pieces of meat or product. I know that Triton has RF thawing machine. So it is being utilized somewhat in the industry but needs more research.

MIKE HENDERSON: Would you come add a few more words to this before you leave so that they have a little more info?

JUMING TANG (JIMMY TAM): Ok.

MIKE HENDERSON: Next one was…

JOSHUA BINUS: So, just a reminder as we're getting into this. So if you've got comments on cards as we're going, either spit it out while we're on it or make sure you write down what your comments are so that you can get it out. Because, you know, especially you guys have been through a little bit of a grueling day and things might start mushing together pretty easily. I just want to make sure we get your thoughts captured. So if it's easier just to spit it out while we're on it, do it then. If you just need to write yourself a note just so we get something entered into the minutes, do it that way.

GRAHAM PARKER: I got a quick question, this is offsetting steam use? Is that the idea?

JUMING TANG (JIMMY TAM): Replace.

GRAHAM PARKER: Replace steam? That would be from a boiler of some sort?

JUMING TANG (JIMMY TAM): Yes

GRAHAM PARKER: I understand why you might have a difficulty looking at the energy efficiency of that. From an electric standpoint.

MIKE HENDERSON: This is a regional road map. Remember we have a much bigger steam cost than an electricity cost.

GRAHAM PARKER: I know the cost side. I understand that.

JOSHUA BINUS: But what I think Graham is getting at is from a BPA perspective because we just look at electricity, but you're right, it's a regional road map that can cover gas efficiency as well.

MIKE HENDERSON: This last one is develop absorption chillers to accomplish freezing with low grade heat. 120 to 140 degree cap. Possibly multi effect. Do you need more explanation? Or move on? Lithium bromide chillers exist that they'll run down to 43 degrees or so. They are commercially available, kind of expensive. Something that would accomplish that with low grade heat and accomplish freezing would be a marvelous invention that the food industry where we're freezing.

BILL WILSON: I'm not sure everyone knows what absorption refrigeration is.

?: We don't have enough hours to explain that.

MIKE HENDERSON: Go on the website, Google lithium bromide absorption chillers and try and follow the cycle and then go ask a coworker to help you understand it. It's complicated, but essentially. No I'm not going to do that.

Perhaps, I didn't want to give you a loaded question.

BILL WILSON: Think of it as a non mechanical refrigeration system.

MIKE HENDERSON: A kind of absorption chiller is what runs a refrigeration in RV refrigerators. But this is different. It is lower input heat.

MARK REHLEY: Do you have that captured, lower input heat? And freezing?

MIKE HENDERSON: I did.

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MARK REHLEY: Ok, because that makes a big difference.

MIKE HENDERSON: Next? On the cooling side. Who's your moderator? I'm done.

JOSHUA BINUS: Just a question. Did you get the R&D programs for the existing technologies facing technical barriers? Could you go through those?

(General laughter)

MIKE HENDERSON: I didn't know I was supposed to do that.

JOSHUA BINUS: Right now is all the R&D.

MIKE HENDERSON: Ok. QL?

JUMING TANG (JIMMY TAM): He's gone.

MIKE HENDERSON: Need to develop prototype to prove technical feasibility and to validate its effectiveness in the heating process such as the pasteurization, cooking, thawing, tempering of various foods. OSU Food Innovation Center.

?: What does that reflect to in terms of a need?

MIKE HENDERSON: CAT2. Variable radio frequency heating.

JOSHUA BINUS: He's not here to give us more. He's actually said he is going to write in short descriptions of what he was talking about. When we're done here we're going to take notes. We'll clean them up. We'll send them out along with the rest of our output when we get the critical comments so you can refer back to this for more information. So we'll get a little bit more from him on that.

MIKE HENDERSON: Next on is John Thornton's on aseptic bulk storage.

JUMING TANG (JIMMY TAM): Yeah, so it would be to develop and demonstrate aseptic bulk storage for North West products or processes. This has been demonstrated and applied in orange juice where there are bulk aseptic storage. The interest is to use in regional products. Rather than typically taking like fruit in cold storage a large part of the year and then brining it out to juice or process, it would be basically to concentrate it or juice it right away so you got a lot smaller foot print having a large cold storage. And then basically, you know there's a lot of applicability in both the apple juice and the wineries and that. So you'd really be kind of taking a known technology and other application and applying to what regionally works.

MARK STEELE: Is that a big space efficiency or is it a big energy efficiency?

JUMING TANG (JIMMY TAM): We haven't really, we've just been exploring it, but I think it's a big space efficiency. When you're concentrating a lot and juicing it's a lot smaller, and pretty good energy.

MIKE HENDERSON: You wouldn't then be cooling a whole building.

JUMING TANG (JIMMY TAM): Yeah, you wouldn't then be cooling a whole building. I think there is still some cooling involved in the…

MIKE HENDERSON: Partner with DOE CHP program to demonstrate multi effect lithium bromide chillers for food plant refrigeration with waste heat. That in relation to what you could do now, but this is what we'd really like to get. That's how those were linked. And then the next one is MS. Research what is needed in the educational system to assure that we will have future employees capable of keeping our energy conservation equipment running.

MARK STEELE: I think that one kind of speaks for itself. It applies everywhere. And it shows up on your other sheet as aging work force issues.

GRAHAM PARKER?: We also tapped into some of that in our area too.

Cooling

PETE LEPSCHAT: Refrigeration on the cooling side of things. I'm going to go the other direction. The problem was the coils that frost up and defrosting technology and trying to save energy on that necessary evil part of it. There's no coil that doesn't frost up, so the study would be the development alternate coil designs that are self defrosting or don't maintain a frosting surface, don't have to be defrosted. That's work for a university or laboratory somewhere. Ok, one was the answer is standardize industrial compressor ratings are needed in terms of horse power per ____ and efficiency. That was based on look at more efficient compressors was the request or the need so we have to measure before we can, I think the idea was to have a standardized measuring before we can determine which is more efficient, and then move forward from there, develop a more efficient one. Explore alternate methods of getting in and out of freezers. That one was based on an unavailable technology that are doors that seal well that are open. That can be done in the field or a laboratory. Regulatory issues affecting the use of alternative refrigerants. Certain fluids are not allowed. And this is not necessarily an R&D program as more of a lobbying for something that goes to high levels and try and get that changed to allow uses of other fluids. Develop alternative working fluids for refrigeration and cooling. That's in laboratories. There was one that's a need for an alternative in air blast freezing. Maybe to use a fluid versus a different fluid besides air for your media to cool with, or freeze with. And also that dovetails in with the regulatory side, in terms of something for an alternative for ammonia. And the last one, find or develop a liquid for immersive cooling of food product, vegetables and fruits. And that's based on that one as well. The available ones, the issue was better defrost controls. The need for a more efficient defrosting or measured and more efficient defrosting, which could be controls, float drainers, optimal piping. The commercial available technology R&D program would be logic configuration control _____ and polyfrost project or something parallel. That's going on right now. Looks like it could be developed further. The only other one of those is the first of many of these existing technologies that are out there but are not widely utilized. Provide funding for demonstrations and need to involve manufacturers, consultants, vendors, installers and end users to kind of overcome the preconceived notions that these might not be viable technologies. And that covers several of these things that we came up with. I think that's all of them.

JOSHUA BINUS: While we were going through these, did anyone have any additional comments that you want to enter into the minutes?

MARCUS WILCOX: We had a couple. This is Marcus. There are people around the country that are using what are called hybrid CO2 ammonia systems. Most of the food processors have two stage ammonia systems, ammonia and ammonia. But if you do the first stage with CO2 and then do ammonia, it's much more efficient at the very low temperatures where you're freezing product. Nestle's done it, United States Cold Storage has done it, a bunch of that stuff back East, but no body in our neck of the woods has done it, nor do they know how to do it. So, we really need a pilot for that. I mean very large energy savings for cold freezing. So, and Mark Steele, I think you put up the one about having vendors, contractors, designers, the end user, and everybody else all on the pilot team.

?: There has to be some incentive to get everybody on the same team

MARCUS WILCOX: Yeah, all it takes is one of those parties to be grumpy and they can neuter the whole project. So, it's a huge relationship effort that under all of these _____.

PETE LEPSCHAT: That's just one example that are there that are similar ilk. Viable in use other places but not here.

MIKE HENDERSON: Marcus, what percentage of energy reduction is available through application of that technology to freezing systems?

MARCUS WILCOX: Oh Jim, help me out here, but I'd say if you're doing minus 45 suction application it's probably 20%?

(Jim)?: Uh, might be a little optimistic, but 15%?

MARCUS WILCOX: On the entire freezing load of that tunnel.

?: And our clients are thousands of horse power.

MIKE HENDERSON: These bromide chillers that ______. You're trying to affect thousands of horse power. I'll bet the capital costs are a lot higher than you just described.

?: Well, and you're bromide temperatures _______.

PETE LEPSCHAT: And one's commercially available, the other one's probably not there yet it sounds like.

MARCUS WILCOX: Josh, most of our stuff, that's why we had a huge amount of stuff in blue is because the technology is there, we just got to get people to do it. Either don't know how to do it, or they're scared of it, or they've got misperceptions. It's been an issue for 20 years.

?: Or the contractor doesn't want to do it.

MARCUS WILCOX: Yeah, it could just be grumpyness, it could be tradition, it could be cookie cutter, but it's been this way for 20 years.

JOSHUA BINUS: Before we move on, any other comments on thermal heating or cooling?

Infrastructure

GEOFF WICKES: Geoff Wickes with NEEA. As a general overview of this is the research programs were a little bit squishy and fuzzy to us because like Mark said it's up and market adoptions and getting everybody to start playing and thinking. A lot of these are more focused on some of the softer skills, so it's not a hard technology. It's not like we had. There were a couple wacky ideas that came out and we thought those were Steven's ideas mostly. So, let me just figure out, we've got some areas dealing with lighting, and we lumped a few of these together. So, there was probably four or five commercially unavailable technologies that are dealing with lighting. We labeled them as continued research so we're not sure who does that, so we just threw them out there. The people involved in the ideas or technology would be fiberopitc light in a refrigerated warehouse or food processing. Another one which was electro luminescent paint. Another one that we had in this same area was individual cubical lighting controls and lighting and hvac controls on site. So, this is dealing with the hvac side of things, so it's crossed a couple of different areas. So we believed there was just more continued research and we didn't know who was doing that. So if people have some ideas, maybe we should get those documented. Anybody from BPA or Mark?

JOSHUA BINUS: Remember, we'll be taking all of this. We've got WSU contracted to help with some fact checking and gap analysis.

GEOFF WICKES: There's lots of fact checking that needs to be done here.

JOSHUA BINUS: So, we'll continue working on this. This is just first draft

GEOFF WICKES: So, one of the other R&D projects we identified was development of benchmarks and standards for the food processing industry. Could be referred to sometimes as KPIs and we thought that NWFPA, NEPA, DOE, possibly NEEA could help out with that. But getting some standards on how much energy is going into a product and then possibly publishing that out and seeing how people rack and stack and how they can improve. And that related up to… I don't know if it needs much more of a definition at this point but I think it's pretty self explanatory. Benchmarks, KPIs, and standards are pretty important. Development of industrial software systems that are used in energy management systems. So right now, as Pam pointed out earlier, you have a lot of software that has been transformed from the commercial market, but it needs to be industry specific, more relating to what we do in the food processing industry, so that we're not just looking at outside air temperature, inside air temperature, occupancy sensors and those kind of things, but has to do with the processes that we are involved with. The freezing, the heating, the cooling. Also, different loads, regression analysis that would allow us to properly fine tune that software. Right now, we're kind of making something else work for what we need. And that came through on a high level here. One of our major needs was energy information systems were very lacking in this area. We've got something that sort of works but it's pretty lame. We had a need for the development of sustainability standards and ways of reporting and the research that needs to get done for that. We don't know who would do that, but the food processing industry is getting approached by different people wanting to know their sustainability report. And there's lots of different questions that come out of that, and so we need a standard that could be accepted and embraced not only by the customers or the end users or even people in the process, but that the food processers can address and come up with solutions. Any questions on that, on our technology part of it. So, R&D for, there's already some work done but needs expansion, we've got a lot on better controls on lighting and more documented savings or case studies for how lighting can be used to improve performance in refrigerator warehouses or production and that we believe there are people currently doing some really good things, but it's not very clear, we don't have a lot of standards around it and so we identified a couple of the individual companies as people who could provide us with the background information but somebody such as HEPRI or NEEA or some outside contractor come up with a standard that would help us do that. And then one of the other areas we identified as a strong need was the development of a delivery of mechanism for continuous energy improvement ISO5001 and other continuous improvement processes. We thought that the ITP, NEEA, utilities and the private contractors might be a great way of delivering that service. Category 4 was. So this was just general. We had several things on just education and training. And we thought that there should be additional outreach and education towards courses and workshops at multiple levels, but even starting as you as K-12, community colleges, and then university and then end use operators, that kind of thing. And we thought that could happen at the university level but also throughout the educational system and then private contractors would be the providers of this. Cat 9. So, there's a couple different things going on in the energy management information space and we identified it in both hardware and software. And one of the areas we identified it was a market survey for industrial providers of monitoring hardware equipment as well as software and we thought that could be done by BPA and NEEA and go out and scan the marketplace and see what is available. But that rolls up into cost effective real time monitoring, data collection, sub metering and metering. As well as a whole other part of it which is the software presentation of that information which would provide people with dashboards, benchmarking and key performance indicators both at the plant level as well as the subsystem level. We got into a section on water because we didn't think it was probably getting addressed in either place. We identified energy efficiency measures that needed to be put in place that would equate water and energy and how that gets integrated into your plant usage, so that it flows into the energy efficiency systems as well. And, we figured we needed to have someone say "Well, what is the value of water for energy and how do we integrate that into the total cost of operations?" And then another area that was kind of broad, but it was pretty important, were templates for sustainability, KPIs, metrics, monitoring plans, and measurements and we thought that MWFPA, DOE and one of the things Pam wrote on here is we need money to do this. Josh, am I answering the process?

JOSHUA BINUS: Yes, I think this is helpful. Like I said, one of the key goals for the process, there's two key goals. One is to get it into the minutes with the spoken word so that we can match up the rest of those cards we have trouble with so it helps to pass the discussion over it. The secondarily is for people to get this into the bindings and ask questions and a little bit of dialogue with the experts in the room. And so you're presenting the information that we need. I'm kind of curious to hear what people's thoughts are?

JIM PETERSON: Did LEED come up with all this or process in this.

GEOFF WICKES: It's ironic. We didn't talk about it. It part of the certification of sustainability issues. We didn't break it out individually.

?(JIM PETERSON): Individual work station controls is part of LEED and in the past, if we attempt to do LEED for existing buildings, that will be very useful and it's pretty hard to do with the way we look at it now, but it may be an expectation of the work force 20 years from now.

GEOFF WICKES: We found that it is sort of this real squishy stuff here, so it was kind of hard to drill down into this.

JIM PETERSON: Just comment on metrics in it's something very hard to do is to have a means for integration of lots of other uncontrollables into the data and metric to give a true energy, a pure energy performance evaluation. Things that like actually occurred whether variations in raw product, variations that are unique to each facility, variations that occur as you change customers and their requirements. These all impact those numbers and have made our current efforts very challenging. We'll put it that way. So there's certainly a need to get our arms around that.

PAM BARROW: Didn't we include that on our list Jim? I thought we did.

GEOFF WICKES: We did. I don't think we came up with a R&D question, but that was one of the things for energy information systems. We need to integrate all those variables and then be able to display and look and evaluate and make decisions about it. And then potentially there was one thing that was automatic control that was to compensate for those variables once you get them figured out. We figured we wouldn't have as many people working in the plant. They'd be working in the server room.

JOSHUA BINUS: I don't know if you had time to do this, I know you were busy working on the other tasks. When we started out and we broke into these three categories, there were questions about whether infrastructure was what we wanted to call this road map. Did you guys do any thinking about a more appropriate name for it?

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JIM PETERSON: We figured that was above our pay grade. (Laughter)

JOSHUA BINUS: Are there any other suggestions? Any one who wants to get into the minutes?

GEOFF WICKES: I would say integration or infrastructure, because it is truly the meshing.

MIKE PENNER: But it's integration, but it's also lighting. But it could be considered infrastructure.

JOSHUA BINUS: Something more glorious than miscellaneous?

MIKE HENDERSON: There are legitimately infrastructure. The management systems, the control systems even.

PETE LEPSCHAT: It all supports the profits, really, lighting, measurement. Support is almost… Process support would probably be more accurate. All it does is support the process. It's all there for that purpose.

GEOFF WICKES: There was a lot of discussion around training and continuing education, and not only bringing the workforce up, but also expanding the workforce in being more sophisticated with a focus on energy.

JOSHUA BINUS: Are you tied into the efforts at Centralia? In the workforce development efforts underway?

PAM BARROW: MPA is.

JOSHUA BINUS: You guys did some nice work today. Who's speaking for mechanical?

Mechanical

MARCUS WILCOX: So, maybe mechanical should be called other? It's meshing a few things together. Just as a starting point, our takeaway from this was there's efficient pumps, there's efficient motors, there's basically the building blocks of your mechanical system are, there's efficient options there. It's really how you put them together that matters. And so, we struggled with what does that mean? Why aren't they being assembled in a way that leads to efficiency and in an efficient manner? So, that led us down the path of training and systems, so there's definitely cross over to the other. But we did identify a few things that uh…. Probably the biggest is this notion that there are mechanical processes in other industries that may apply to food processing. We came up with a couple. One was around laser food processing. So, you can use lasers to mark a product, as opposed to slapping on a paper label. And I guess there's a method for perforating the surface of food, that it's basically creating a more porous outer condition for drying or freezing. Those are the couple of things that came up. So, the use of lasers to pre-process. So, we felt like those are in the market and there's a need to basically do a technical assessment about whether that really is useful in the food processing industry. OSU is working on that right now, so that's one of the other areas. There was one other one that was kind of completely different, then I'll go through the rest. Graham brought up separations. There's different ways of separating substances. Liquid substances using membranes as opposed to just letting them settle. Maybe, Graham, you can speak more to that?

GRAHAM PARKER: Separation technology has been applied to industries other than the food industry. Whether it's membranes or whether it's other separation strategies. For example, separating water from ethanol. Very important for the ethanol industry and it's energy intensive but it can be done with other means. Has been demonstrated. Now, can we move that to the food industry when you essentially got a slurry of some sort. Well, then you got to separate the products and then you can recycle the water. Now, we just don't know because so much of what we have in our back room came out of the nuclear industry. The nuclear industry and the food processing industry have never intersected, except for irradiation of food. You know where that ended.

BILL WILSON: You might also call that concentration, rather than separation. In the separation there is a solid solution, solute. That's a substitution for evaporation.

??: So, are membranes. Is that something that is used pretty commonly?

BILL WILSON: It's used very much in the dairy industry. In cheese making.

??: So this may not be, may be already there.

GRAHAM PARKER: Maybe it's the lower cost. Separation technology, in terms of membranes technology you can actually afford and lasts without replacing your membranes. So, still some work that could be demonstrated.

MARCUS WILCOX: As far as research projects, so we had technology around motors that would respond to, basically smart motors. Motors that would respond to a demand response signal that have enough intelligence in them to know when they couldn't accept that signal, so they'd be tuned into the process as well. Most of our research, we don't know who would be the appropriate one to do it or what kind of research would be applied there. We have a lot of gaps down here, but that was one area of research. Advanced conveying technology. This is a pretty open one. I think this must have come from somebody else, I don't know, it's got some different numbers up here. So I don't know, some of these things just appeared on our chart. We appreciate that.

GRAHAM PARKER: This is Graham again, I think it was mine. I think like a lab guy. You move product around all over the place within these plants and it takes motor power to do that, so you look at the efficiency of the motor, which is one thing, but if you look at the efficiency of how it's conveyed and the different conveyance technologies that might be out there. Better rollers, better belts, kind of not traditional way of looking at things. Sort of in a systems approach. So coming from a chem engineering background, I kept drawing boxes around things when I was in school. I still think we need to draw boxes around things, work on the inside of the box. Look at everything.

MARCUS WILCOX: Another was non invasive sensors for flow and pressure. So, an example of this would be under compressed air systems. It would be, it would be really useful to be able to put sensors, to have an existing system that you could put pressure sensors on, that you didn't have to drill into the pipe for and add additional potential for leaking. You could diagnose leakages much easier that way without impacting the system.

JIM PETERSON: Can I say something now? We actually talked a little bit about that over here. How could we get some meters that really provided some good information so we could quantify it. Metering technology is really important, non invasive especially.

MARCUS WILCOX: Yeah, the non invasive part we thought was, made it easier, would take away some of the barriers to adoption, so you didn't have to tap into your system and break down for production. So, an interesting one that came up was is there a way to, an alternative storage mechanism than refrigeration? Ear muffs. (Laughter) Let's try canning! (Laughter) Let's try irradiation! (Laughter) Not sure what that looks like, but that was one that. There was a notion there around can you store product and then run your mechanical systems on a more regular basis as opposed to these spikes.

??: So, that's part of the premise behind aseptic storage too.

JIM PETERSON: We have to over come a public perception concern over food that won't rot.

??: Yeah, it needs to spoil, otherwise it's not really fresh.

MARCUS WILCOX: And then we did get into the notion, the idea around forklifts and transport within the facility. A lot of that is electric. And, so the question is, are the chargers smart? Are they efficient? Smart chargers would pay attention to the peak load. So, we think there's some research that is probably needed, that it's something that is being looked at on the residential, the public transit, not the public transportation, but electric vehicle for homes, but not necessarily on the industrial end.

PETE LEPSCHAT: I'd like to make a comment on that one, just in terms of the. Like we did with compressors, they develop an efficiency standard for battery chargers because there aren't many of those. I equate it to you going down to Sears and buying a 6.5 horse power shop vac. Well, if it plugs into the wall, no way. So, it's the same thing. Some of the charger manufacturers are, there are widely varying efficiency ratings that don't make any sense and needs some standardizing.

PAM BARROW: Did you guys look at the rapid chargers?

??: Um, we didn't get down to that level of detail.

PAM BARROW: What we did a couple of years ago when we were working with Del Monte in California. We did a research project on rapid chargers and rapidly charged batteries in the, for electric fork lifts. This is a technology we took from the airline industry and applied it to food processing and what we found were really huge improvements in efficiency and reduction in costs and I have not been able to get that technology widely dispersed. We need some case studies on that. But it's a really great thing.

GRAHAM PARKER: And I think we want to go beyond that to the smart charger as well. So, it also can tell when you shouldn't be charging at all because of demand on the system is high at that time, you're going to get demand charging because it's, so it's a combination of both. Two years ago there was no such thing as a commercially available smart charger like there is in the residential sector.

PAM BARROW: Yeah, I'm have trouble linking up with your concept, that concept with the one we're looking at but it was where you could instead of having a whole room full of batteries that you've got to charge that you would have these rapid charge batteries and that the forklift operators could recharge on their breaks. It was that quick of a recharge and there wasn't the decrease where you have your using the energy from your battery you get reduced efficiency. We didn't see reduced efficiencies. We have high levels of efficiency throughout the operation, so…

??: Do the lights dim when you charge? (Laughter)

PAM BARROW: No, but it was great. I mean, really a great system and it would just by.

COREY CORBETT: This is Corey Corbett with Puget Sound Energy. There is, for forklift batteries, there is a technology called high frequency battery chargers that has some intelligence built into it where if there's not a battery connected to it or if it's fully charged it'll _____ like a smart charger. I know, I think there's a work paper that PECI did for California Energy Commission and I think there's two or three points that are readily available out there.

PETE LEPSCHAT: We're using Ametek for the chargers. A-m-e-t-e-k. Used to be Hobart.

??: And Ecos has also done some research on this a couple of years back where they looked, they surveyed the whole market and did some analysis. They found exactly what Pete was saying, there's no standards out there. Or the standard is whatever they say.

PETE LEPSCHAT: Yeah, because you'll read specs on a charger from three different manufacturers and you go out and actually measure it in operation and um… You know, under lab conditions maybe, but not in reality. There's huge variation between even, not between necessarily brands but even within families of high frequency chargers, _____ resident chargers, SER chargers, brand A, brand C, brand B. And within that even different models of the same manufacturer, there's a huge variation in efficiency because they're using some standard chassis and making larger or smaller depending on what they're using it for and that effects it drastically. That's not published. That information's not out there unless you go find it yourself.

MARCUS WILCOX: So it sounds like added additions, you've got more technologies in the market than we were aware of that maybe need a little bit of additional work, case studies or whatever. So is that… you're listening to this and…

JOSHUA BINUS: Yeah, I'm listening and I'm hearing the typing and seeing the writing down. I want to just enter one more thing into the minutes on this discussion too, and maybe Pam, this might help, make a little sense to where Graham was coming from with the smart charging aspect of it. In the North West, as capacity is becoming more of an issue with the electrical system, largely because of all the wind coming on to our system and load growth in general, salmon issues, etc. Any spending of electricity coming off the river system is creating capacity issues that are likely to increase over time. We married that up to our new tiered rates coming out from Bonneville which start this October and 20 year contracts moving forward. I think what you're likely to see with the food processing industry, especially located within load following utilities for Bonneville _____ is an increasing of dynamic rates being put in place by utilities so some of your members are likely to be seeing timely use rates and critical peak pricing, things like that. So there'll increasingly be incentive to avoid the peaks. There may also be incentives to be able to manipulate load to increase load during certain periods to help balance out the system. It's hard to say but I think this increasingly over the 20 year horizon we're going to seen more need to address capacity as well. Or at least respond to price signals.

GEOFF WICKES: One other think to consider with all that, I understand pricing and demand and load but, in industry, a lot of need happens and now they're going to more than 24/7 operation, so even though there's an optimal time to charge, there may be you just need that charge because you need to move product and you can't have any more square footage dedicated to more trucks, you just need chargers.

PETE LEPSCHAT: However, there's ways to manage that within your facility by balancing load and other things control wise that can negate that being, from being a negative for demand aspects.

GEOFF WICKES: I just know people like Supervalue or System Foods, it's not about _____, it's about trying to keep trucks on the road.

MIKE PENNER: I noticed that we didn't really address peak demand, I know _____ CHP but not peak demand.

JOSHUA BINUS: It wasn't a key focus, but we, as we've done with the other energy efficiency road maps, we didn't say "No, don't do anything that touches on demand response and smart grid technologies, but allow for any grey area." At some point, we're probably going to need to tackle those technologies head on, but right now the focus is really energy efficiency.

MIKE HENDERSON: This is Mike. We had a train of thought over there leading to energy storage on site for demand peak leveling. There's some nano technology work that Oregon Freeze Dry was involved in around high surface area carbon used in capacitors and I don't know all the details, but that is an area that you may want to continue research in for exactly the kind of purposes that you're talking about in terms of demand response where often we are not able to control our operation but we have a need. But it could solve the problem on a more global level too. Did you want to add?

GRAY JOHNSON: Some scientists came out of University of Washington and they got grants to basically create designer carbon that filled the need. Right now, the carbon is basically ground in coconuts and purified and purified and purified and burnt and that's where the carbon for storage comes from and. So, they made the carbon as pure as they could up front, and they get more surface area. Freeze drying is part of the process. Activation and they're setting up a facility, it's a DOE grant and they're setting up a facility next to Freeze Dried down in Salem, or down in Albany. And they're working on either battery anodes to make basically super batteries that would have rapid charging capabilities and, in a very small package, or in a much smaller than you're accustomed to. And you're also ultra capacitors so that as of for instance, instead of the heavy metal type batteries in an automobile, when you open up the trunk, you actually have half the number of batteries and then you have a compact ultra capacitor there so that you're actually collecting the mechanical energy from stopping and things like that to give you a little kick when you start it at the stop light and then you have the actual chemical energy there that gives you, to maintain the fly wheel going as it were. So, they're going after the automobile market, they're going after the wind energy capabilities of storing power and then delivering it to the grid when it's the right time. You can look it up online but it came out of a, University of Washington. They have an industrialization center and they came to us and got hooked up to us because of the need to freeze dry this nano _____.

JOHN THORNTON: This is John. So, what I think you're really saying is capturing the ability to energy storage and it could be thermal as well as electrical. I mean thermal storage could be covered out of that too.

MIKE HENDERSON: Well, the whole concept has ramifications throughout what we're doing and maybe that's a worthwhile thread to take out of this and put in this roadmap someplace to be supported of, identify that as potential funding need that might have excellent multiplier across the region, especially for BPA and trying to incorporate renewables, even within our plants and trying to respond to tier grades and to get down to kind of a down in the weeds deal that could have, if it's economical, could have dramatic potential.

JOSHUA BINUS: We currently have a project underway where we have funded a partnership of the North West Power and Conservation Counsel Ecofis a commercial aggregator called Enternoch and several utilities that are working with them to do some test with some cold storage wear houses to basically use the thermal storage available in those wear house spaces to respond to our need to expand our balancing reserves to deal with wind. And so I will be reporting out some findings on that. It's a technical feasibility test. What does that run through?

MIKE HENDERSON: The potential available with something like this is magnitudes above what you're going to get by demand of cold storage.

JOSHUA BINUS: My point is, we kind of have one track of that under way and I think this kind of expands that effort.

MARCUS WILCOX: Aren't you also testing residential water heaters?

JOSHUA BINUS: We've got, yeah, I mean, we're going after residential water heaters and other industrial strategies to expand our balancing reserves. I'm pretty sure one earlier, it might have been with your team, about a paper plant that we're looking to utilize the way they're able to do batch processing, you know, essentially, it's a paper plant that has large grinders

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that they use to create pulp and put in storage tanks to you know run off the front of their processing lines and we're testing a feasibility test to get about 40 megawatt drop in load and 30 megawatt increase in load to respond. And we're doing a similar test where we're going after water pumping and reservoir storage at about 2.5 megawatt, up and down. So I think that there's, when we're looking at capacity moving forward, I think there's probably ways within this industry where you all might think about, of utilizing you're available batch process capability to tweak that slightly in a way that doesn't affect your processes but that you may have some flexibility in responding to some of future price signal that ends up coming that we don't have a price signal yet, we're just doing feasibility research on that.

MARKE REHLEY: Well, let me just finish out, given that there are efficient pumps and efficient motors, lots of efficient building blocks, we had asked that question, why aren't those being used readily? And that's where training came up. So we said that a certification program would be useful, potentially, and that should be tested to see if that would increase training and lead to greater adoption. Some sort of cash incentive for training, something to motivate people to get the training so we captured both of those. NEEA is actually working on, they're starting a review of a certification process for refrigeration and Idaho power is apparently is using some pay incentive to get people in for training. So, it's a question of whether that leads to a change in behavior or not. And then strategic energy management we felt was also a key component to motivating people to look continually at the processes and incorporate some of these building blocks as they could. So that's something that NEEA, Bonneville, Energy Trust of Oregon are really active in and North West Food Process Association with their 25 intensity goal. Around compressed air, there's a sense that, there's probably room to look and see if there's anything new. There's pretty well established programs around the compressed air challenge, it's gone national. But whether there's any new technology there, that's a question we asked. We figured there'd be worthwhile research. And then the last thing we had on our list is fan walls. This came out from some session at the Bonneville Conservation Summit?

JENNIFER ESKIL: The Industrial Forum last January.

MARKE REHLEY: And we could quite figure out what they were but we got some feed back from a couple of people that we should put in on the list and we should investigate it. I don't know exactly what they are.

??: You said fan walls?

MARKE REHLEY: Fan walls. A wall of fans that you can move around.

??: Was it used in blast freezing?

??: In relation to cold rooms?

JENNIFER ESKIL: That's why we need to research it.

(Everyone wanted to know what they were for)

COREY CORBETT: In hospital applications. Where typically you need redundancy in the system, so we usually, with a hospital air handler, you have two motors, but with a fan wall, you can build up your capacity with multiple fans and then you can have n+1 redundancy where you just got one extra motor as a spare so if one motor goes down you can replace that.

??: So it's for air distribution?

COREY CORBETT: Yeah, for air handling applications

MIKE HENDERSON: I don't see it jumping out _____. It's quieter, if you got lots of space and you want that, you've got fewer drives.

??: I thought there was an assertion of higher efficiency.

JENNIFER ESKIL: Yeah, there was, and I can't remember.

MIKE HENDERSON: I don't know if I bought it.

COREY CORBETT: I mean, there's some efficiency gains there, but I think you see it a lot in hospitals where I think a bigger driver for it is a redundancy aspect so they don't have to have two larger size motors. If one goes down, they can replace it with just a small, little motor.

??: So, cost reduction around spare parts.

JENNIFER ESKIL: The example we saw, it wasn't just a hospital or commercial application, it was an industry that was using it so our thinking was could it be applied to the food processors.

??: Any other questions on mechanical?

MIKE HENDERSON: You could cross reference over there we had a deal on compressor efficiency to and it would fit under air systems under mechanical to try to drive manufacturers to improve the efficiency of compressors.

??(MARCUS WILCOX): We cross referenced into some of these as well.

JOSHUA BINUS: So, I think all the groups brought interesting things that frankly, for as much joking around as the last group was doing, I found the report out on the last one pretty interesting. You know, one of the things that came up that you guys didn't share actually was that, I think already there's some amount of prioritization, which is the next thing I want to talk about, and just the way that you guys organized what you were doing and what we were seeing as far as R&D programs. As it came out a couple of times, early on there didn't appear, people were thinking there was not a lot to do on a mechanical side. When that group dug into it, and they didn't, and I don't feel like the report on this at least said it quite this way, most of that stuff is really dealing with programmatic efforts or barriers that need to be undertaken and there's not a lot of technology related programs that needed undertaking. Which, I don't think really comes as a surprise to anybody but from this output perspective, he was a little bit stressed out. Watching these guys and was being the heavy over there. Which is ok. I think in the end I think what it does is it really gives us a good hand off to communication to NEEA and some of our programs folks to reiterate some of the problems are within the industry. I'm guessing that some of it is not going to come as a surprise whatsoever. They're already kind of facing them, but we can communicate that across. And it does kind of help highlight that there was not a lot of R&D in that space and that thermal had, heating and cooling is really where a lot of the priority projects lie along infrastructure.

And when it comes to really honing in on what our priorities are we didn't want to put you guys through yet another task today, and frankly we didn't think we had the time to do it. And so what we're going to do is, following this workshop, we're going to do, first we're going to go through and clean up the notes and get them condensed together. Ibrahim is going to do his best at transcribing everything they've got on the wall and putting in, synthesizing it in a way that we can communicate out to you all so you can look at it from a critical perspective and see is this really what we meant for each one of these R&D programs and technologies that we're looking at. Could something be word smithed a little bit, I'm sure a lot of this stuff can be.

What we'll do, we'll then send it off to WSU who's on the book, to help us with some fact checking, probably some gap analysis on the R&D programs. One of the things I noticed was happening in the way things got presented out is people were making suggestions for places that could do the R&D. Really, what we were looking for was knowledge of places where R&D programs were actually being undertaken, so there's a little bit of confusion there, but it's ok. We'll make sure to take a close look at that and to carve out where the suggestions were and where there is actually R&D. That's where we get into a little bit of risk management in regard to our funding of R&D programs.

Like I said before, we don't want to spend money on R&D programs that are already going on somewhere else. And likewise, we don't want to convince our self that an R&D need is being fulfilled somewhere because we've made an error and saying yeah, so-and-so is doing this, this is happening in a lab somewhere. When, in fact, it's just a suggestion. We'll go through and clean it up. We'll get results back from WSU. Once we have that back, we'll take another pass at it as a team, clean it up a little bit more, and then we'll communicate it out to everyone here and ask for your help in prioritizing the R&D programs that have been identified in this process.

So, it's likely to be a couple of months. It could be, because I know, Ibrahim's got some time he wants to spend with his family and he's going to do a lot of the heavy lifting post workshop. You know, everyone else has been taking vacation this summer and Ibrahim has a chance to do the same. But, we're going to get that out to you and, with some directions of scoring criteria, etcetera. Keep your eye open in email for that.

We’re also going to have a follow on workshop now for combined heat and power, onsite generation, renewables, etcetera. You know what, we’ll follow up in one of our emails looking for volunteers. Some of you that have come today might be very well positioned skill wise to participate in that workshop. If you are we’d very much like to have you again. The second time through a process like this is a little bit easier than the first time. You kind of know what to expect. But if you’re not the appropriate person from your organization to really sit on that workshop, just let us know and if you have a recommendation of some got to people you think that really have the knowledge set that would really be applied in a workshop like this on that topic, please feel free to forward on that recommendation to us and we’ll track them down and ask them to participate.

And then the goal here is basically to have these four road maps we’ve worked on today, the two within thermal, infrastructure, and mechanical, married up to whatever road map or road maps come out of that follow on workshop and have them melded into the March 2012 edition of the North West Energy Efficiency Technology Group. And _____ website at BPA. _______ (about finding the roadmap)

MIKE PENNER: Josh, I was just curious, just kind of realistically thinking about the follow up. Once you get back to busy life, catch up on all your emails, it seems like for me, if somebody sends me something and says, when you get a chance, hall through this long list and, yeah, I’ll put in on the list and one of these days I’ll get to it. It just kind of doesn’t get done. As opposed to say, on September 28th from 2-3 we’re going to go to a meeting and it’s all nicely laid out in columns and we’ll roll up our sleeves and just get the team back together and just do it. To me, there’ll be a much greater likely hood that I’ll do it, we’ll get the juices flowing. I don’t want to mess with the process.

JOSHUA BINUS: I think that’s a fantastic suggestion. If you guys are able to, we can put together a webinar to present to you kind of the out come of this and I’ll have the scoring process ready for that and then we’ll just all do it live while we’re on the phone and you can funnel it in. There would probably, Ibrahim was talking about doing it through, possibly through Survey Monkey.

MIKE PENNER: I was thinking, just have team infrastructure get together and flush that out a little bit more. Just the three groups. And then do the scoring thing.

JOSHUA BINUS: So, one more webinar to pull from the critical comment. And then follow on for prioritization onward?

MIKE PENNER: Yeah.

JOSHUA BINUS: I’m open to that.

MIKE PENNER: You know, when you’re a little more fresh. It was kind of, we hauled through a lot today. It was slowing down a little. If we could hit it at 10 o’clock one morning. And if it was all nicely laid out for folks with this goes to where. Just lay it out nicely.

JOSHUA BINUS: Well, we’ll present to you a straw man for how we’re going to present it as a follow on. We got those suggestions entered in on the minutes. We have two on that. We’ll talk about it some more. I think I’ll pull the planning team together again one more time to go through the remaining process on this and start teeing up the next workshop just to get the other pieces didn’t get punted down the road indefinitely.

PAM BARROW: What if we have other ideas that come up. I don’t know. This is just what we came up with today, and there are lots of _____ of food processing that aren’t here today. So I think there’s lots of opportunities to get additional ideas from food processors on technologies and R&D and how can we incorporate those. I mean, what I’d like to do is to get the output from this group, and then take it to our membership and get feed back from folks because we don’t have all the brains in this room. Some of the bigger ones. But there are a lot of folks that are not involved. And if we’re going to say this is “Food Processing Technology Road Map,” I’d like to have wider input in the food processing industry.

JOSHUA BINUS: Maybe what we can do to accommodate that would be to have a process where we push back the prioritization a little bit longer and to allow for a little bit longer of a critical comment period on this first draft of the road map. We’ll pull together, tighten up, have maybe a, when we have that webinar, present it. You can invite your other colleagues that didn’t have a chance to sit in. We can present our findings so far, explain the rational of what we were doing with that context. Give them a better ability to provide critical comment, invite that critical comment, give it maybe a two week period. And then, once that’s done, get that in, fold it in, and then get that survey out for prioritization. Then we can lock it down for the March 2012 release, with keeping in mind that this is a working draft so as things come up and as new ideas come up we can enter them into the road map for each successive draft.

PAM BARROW: Yeah, that sounds good.

MIKE PENNER: Maybe we're supposed to do this ourselves, but some of the projects seem like very broad with, like the energy storage systems. Other ones seem more specific. More specific to certain aspects. It'd be nice to get some feedback on some of the things we're not that clear with. Are there ones we can lump together? I might have heard wrong, but the microwave and the radio frequency. It would seem, rather than have those as separate, wouldn't it be better to combine them and say it is more generally applicable.

JOSHUA BINUS: And maybe we can do it, before we go into the prioritization effort and the survey, maybe present a straw man on how we are proposing to do the prioritization at the webinar when we present the first pass of the road maps, so we can also invite critical comment on that, because what we did in the past, it was for prioritization. We've only gone through the prioritization of this whole system road map one time so far. It's going to need your refreshing. And I think treating the prioritization of these is, and kind of going at it with a new perspective and bouncing that off and hearing some critical comment, will not only be good for this road map series but also when we revisit this next time. There's a lot of things in the existing road map portfolio that have kind of crept in over time since our first pass at it, so now there's a weird mix of R&D programs that got prioritized and R&D programs that got put in since that have no priority put to them what so ever.

So the whole thing is going to need to be reprioritized for March 2012. And maybe what we end up doing is folding it into everything but why don't we talk about that at the webinar meeting because I'm guess that the industry is going to want to put a priority on top of it's own needs that's beyond what the other regional stake holders that scored the rest of the portfolio would do. We'll need to wrestle with that.

Alright, well, we did end up getting done early today. At times this morning I was wondering if we were going to be going all the way to five or six or not, but I think you guys did a really great job. I apologize from my side for whip cracking all day, or at least it felt like it, so hopefully you can save the flaming emails for post workshop. Or send them to Ibrahim. Really, it was a pleasure getting to meet a lot of you that I've only ever met on the phone and it's really nice to be able to put a face to a name. I'm not going to keep belaboring how much we appreciate you guys coming, but I hope you do consider participating in the next workshop, that it wasn't too exhausting of an experience. And would make recommendations to other colleagues to join us when we do the next ones, because really, the more people we have participating, the more robust conversation experience etcetera we can bring to bear.

Thanks again. If you don't mind, tossing out garbage or recycling in the appropriate spot on the way out, that'll kind of help us in cleaning up the space afterwards. And, if you have any questions that come up post workshop or comments, you can either email them to me, give me a call on the phone, whatever you need to do. Oh Terry! Thanks Rob. I saw you walk out and walk back in. By the way, this is Terry Oliver, who's our Chief Innovation Officer.

TERRY OLIVER: Poobah. Grand Poobah. I'm the Chief Technology Innovation Officer. My office research the research and development portfolio for BPA. Joshua and his team have been doing great work on the energy efficiency part of that. BPA is one of the few utilities in the country that's decided to go this way and actually invest in R&D, so our target is now to spend upwards of half a one percent of our revenues, about 17 or 18 million dollars a year, on research and development that applies to BPA and to the Pacific North West, with a heavy emphasis on BPA. Energy Efficiency fits into that a little more broadly than other things simply because we're responsible for acquiring half of the resources in the North West, so big important thing for us to get done. So we really appreciate. The only way we get to refine what it is that we want and need to sponsor in terms of research is to understand what the gaps are and how it applies and why it's important to BPA. We've done R&D before and where we've gotten into sort of moral hazards is trying to R&D for everything, for everyone. And so in this incarnation of it we're trying to stay really focused on what's important in the North West and what's important to BPA. We go through a process of Joshua said well, we have to have pencils down on the road maps in March because we open to solicitation and the road maps are the guidance we use to clue people in to what are we interested in. There's a transmission, a _____ road map, a security road map and an Energy Efficiency road map. This'll be the latest component in that Energy Efficiency road map. Thank you for all your effort of helping us understand what those issues, gaps and opportunities.

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Drivers

Environmental & Global Drivers:	Driver Code
Climate change	EG1
Peak oil	EG2
Energy security;	EG3
Water scarcity and cost, related health concerns	EG4
Increasing cost and decreasing availability of raw materials	EG5
Environmental impact of centralized power generation	EG6
Fuel switching from combustion to electric	EG7

Market Drivers:	Driver Code
Increasing and uncertain future cost of electricity and gas	MD1
Proliferation of consumer electronics (increased plug loads)	MD2
More and cheaper products due to globalization of manufacturing	MD3
Increase in available funding for EE	MD4
Changes in types of industries in the Northwest	MD5
Market awareness (e.g., BPA E3T, utility demos and outreach)	MD6
Energy efficiency promoted through mainstream media	MD7
Non energy benefits of the technology	MD8
Risks associated with implementation of the technology need to be reduced	MD9
Need to sustain competitive advantage over competitors	MD10
Product quality need to be enhanced	MD11
Change in growth of processed foods	MD12
Population growth	MD13
Increased transportation costs	MD14
Demand from consumers towards more sustainable/local products (green)	MD15
ROI of the energy efficiency investments need to meet hurdle rates	MD16

Behavior / Social Drivers:	Driver Code
Employer pressure to increase productivity	B1
Consumer desire to be “green” and reduce embedded & used energy	B2
Consumer desire for comfort and aesthetics	B3
Changing demographics impacting purchasing choices and behavior	B4
Increased awareness of impact of behavior on energy usage	B5
Aging workforce, lack of trained workforce	B6
Pushback against over-regulation	B7
Lack of energy efficiency knowledge in the industry	B8

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Policy & Regulatory Drivers:	Driver Code
Carbon emissions penalties and/or incentives	PR1
Use of codes to lock in efficiency gains	PR2
Increasing budgets for emerging technology R&D	PR3
Integrated resource planning	PR4
Increased interest among legislators in efficiency and renewables	PR5
Limits to existing transmission and generation capacity;	PR6
Smart grid technology development	PR7
Environmental Regulations	PR8
NWFPA goals to reduce industry wide energy intensity by 50% in 20 years	PR9
6th Power Plan of NWPCC	PR10
Increased scrunity by regulations	PR11

Technology Innovation Drivers:	Driver Code
Diffusion of common communication protocols into energy-consuming devices	TI1
Integration of info, communication & entertainment devices	TI2
Availability of new technologies such as solid state lighting	TI3
Availability of cross-cutting, low-cost technology building blocks (i.e. wireless, ultra compact heat exchangers, advanced controls, ASDs)	TI4
Need of automation technologies into processes	TI5
Nano technological applications in the food processing industry	TI6

Heating Technologies

Capability Gap Code	Capability Gap	Linked to Driver	By
CG1	Need cheap energy storage to cut peaks. Enable direct use of intermittent on site generation	MD3, AA1	MEH
CG2	Eliminate need for central steam in food processing plants	AA1, MD3, EG1	MEH
CG3	Find ways to cleanly use coal, perhaps integrated with food processing	EG3, EG1, AA1	MEH
CG4	Lack of wide spread knowledge/acceptance/implementation of known waste heat recovery teachings in the operations (compressors, boilers, as well as cooling technologies)	B6	BW
CG5	Enable a heat pump technology that can heat frying oil to 400 F and drop steam system lower pressure to save energy	MD3, EG1, AA1	MEH
CG6	New pasteurization technologies to reduce energy uses in canning operations. R&D work is needed on microwave and RF based heating methods to reduce heating time and improve safety and quality of the processed food.	EG7, MD9, MD11, MD12, B7, PR3	JT
CG7	Need a more efficient (than steam) working fluid to move energy around a plant	MD3, EG1, AA1	MEH
CG8	Develop inexpensive and higher efficiency non .... heat exchangers	MD3, EG1, AA1	MEH
CG9	Find ways to reuse lower grade heat (120 F to 190 F) in processes	AA1, EG3	MEH
CG10	Technology to take advantage of power pricing during energy	MD1	RT
CG11	Need more energy efficient bulk storage of food items with short shelf life at ambient temperatures	MD10, MD12	John T
CG12	Lack of automated closed loop central system to monitor product temperature out of freeze tunnel and adjust freezing process	MD10	John T

Commercially Available Technology	Commercially Available Technology	Linked to Capability Gap	Barrier Type	By
CAT1	LI or Lead acid battery packs	CG1	Technical	MEH
CAT2	Variable radio frequency heating	CG6	Technical	QL
CAT3	Condensing type economizers recovering sensible and latent heat from boiler exhaust steam (waste heat either used in boiler operation or processes)	CG4	Other (Financial)	BW
CAT4	Hyperbaric pasteurization	CG2	Other (regulatory)	
CAT5	Aseptic bulk storage- this technology has been applied to orange juice and interest is developing technology for apple juice and other PCW food products	CG11	Technical	John T
CAT6	Lithium Bromide or Simlan absorbtion chillers	CG9	Technical	MEH
CAT7	Smart distributed steam generation (i.e. MIVRA)	CG2	Technical	MEH

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Commercially Available Technology R&D Code	Commercially Available Technology R&D	Linked to Commercially Available Technology	Where is the research?	By
CATRD1	Need to develop prototype to prove technical feasibility and to validate its effectiveness in heating process such as; pasteurization, cooking, thawing, tempering of various food	CAT2	OSU Food Innovation Center	QL
CATRD2	Develop and demonstrate Asoptic bulk storage pilot scale for apple juice, wine	CAT5	GAP	John T
CATRD3	Partner with DOE CHP program to demonstrate multi effects LI-BR chiller for food plant defrigeration with waste heat	CAT6	GAP	MEH
CATRD4	Research what is needed in the educational system to assure that organizations will have future employees capable of keeping energy efficient equipment running		GAP	MS
CATRD5	Develop absorbtion chillers to accomplish freezing with low grade heat (120-180 F)	CAT6		MEH

Commercially Unavailable Technology	Commercially Unavailable Technology	Linked to Capability Gap	By
CUT1	Universal Oven (Combination of RF heating and convection)	CG6	QL
CUT2	Better batteries or capacitors or any similar technology that has less than 2.5 years of payback	CG1	MEH
CUT3	Over past 15 years WSU developed novel sterilization and pasteurization technologies based on microwaves (replacing steams). The development was supported by DOD, US Army, USDA and major food companies, Nestle, Hormal, Kraft, Pepsi, General Mills… A game changing technology that reduces heating time by 80%, improve quality and food safety. It needs R&D on improving its energy efficiency	CG6	JT
CUT4	Smart distributed steam generation to lower compressor costs and complexity	CG2	
CUT5	Lithium bromide or similar absorbtion chillers that can economicall achieve freezing (now typically 0 F)	CG9	MEH
CUT6	Binary Fluid Ejector Heat Pump (Thermally Driven)	CG10, CG9	BW

Commercially Unavailable Technology R&D Code	Commercially Unavailable Technology R&D	Linked to Commercially Unavailable Technology	Where is the research?	By
CUTRD1	Development of the universal oven to demonstrate this effective technology	**CUT1**	OSU Food Innovation Center	**QL**
CUTRD2	Need to develop an energy efficiency and optimization project to support technology transfer and implementation of microwave sterilization/pasteurization pilot scale demonstration technologies.	**CUT3**	WSU Food Engineering Faculty, Ocean Beauty Sea Foods	**JT**
CUTRD3	Develop proof of concept for Binary Fluid Ejector Heat Pump	**CUT5**	May-Ruben Technologies , Chelsi Ribbon: 250 702 2670	**MEH**

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Cooling Technologies

Capability Gap Code	Capability Gap	Linked to Driver	By
CG1	Refrigeration Evaporator Defrost Technology is not well understood in the industry. This leads to the installations of less than efficient systems.	**MD1**	**PL**
CG2	Develop .... for NH3 that is non hazardous, cheap and common/Develop systems that can use CO2 i.e. .... possibly multiphase or combo mixture.	**MD3, AA1**	**MEH**
CG3	Need gas driven refrigeration refrigerator options that also provide waste heat.	**Technology adoption**	**MW**
CG4	Heating and cooling contractors only focus on each, there is no integrated approach that focuses on both	**MD9**	**RT**
CG5	Air-cooled refrigeration compressor oil cooling (with glycol)	**Energy Water Cost Savings**	**MS**
CG6	Use electrodialysis for cold stabilization instead of tank chilling	**MD10, MD11, MD16**	**JT**
CG7	Need new and less expensive insulation materials or refrigerants for tank and pipe insulation		**JT**
CG8	More attention needs to be given to the management of infiltration loads into refrigerated spaces-quantifying cost of infiltration.	**MD1**	**PL**
CG9	There needs to be an outreach to work to colocate facilities that have waste heat near facilities that need heat for process-District heating	**MD1**	**PL**
CG10	Equipment to upgrade heat content in waste streams to higher, more useful temperature ranges	**MD10**	**MS**
CG11	Use of ammonia absorbtion rather than traditional mechanical refrigeration	**MD1**	**BW, MW**
CG12	Use of cascade CO2/NH3 refrigeration for low temperature freezing (less than 25 F)	**Technology adoption**	**MW**
CG13	A small number (less than 6) of regional rfrigeration contractors do all the work. They are conservative and risk averse and they prefer proven design and technologies	**MD9**	**MW**
CG14	Existing compressor technology is inefficient (Air refrigeration)	**AA1, EG1, MD1**	**JP**
CG15	Freezing with air flow is inefficient and slow. Need liquid or direct contact methods that are faster, eliminate power and higher freezing temperature.	**MD3**	**MW**

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Commercially Available Technology Code	Commercially Available Technology	Linked to Capability Gap	Barrier Type	By
CAT8	Cascade Refrigeration Systems are available.	**CG12**	Other (regional expertise, regional examples-misperception in industry)	**PL**
CAT9	Better defrost controls, fluat drainers, effective (optimal piping) frost piping	**CG1**	Other (contractor unwillingness , lack of education or buy-in-better ROI numbers)	**PL**
CAT10	Gas driven screw compressors with heat recovery from engine	**CG11**	Other (non-standard and use of low grade waste heat)	**MW**
CAT11	Hydro carbons and other chemicals	**CG2**	Other (regulatory and public perceptions)	**PL**
CAT12	Implementation of energy efficiency in industrial refrigeration design by regional contractors	**CG13**	Other (refrigeration contractor limitation to implement technology; tradition or risk)	**MW**
CAT13	Needed heat exchangers is available. Regional contractors need to offer as a design options	**CG5**	Other (need regional examples)	**MW**
CAT14	Fast acting doors-vestibules-air curtains, high rise warehouses, ASRS systems	**CG8**	Technical	**PL**
CAT15	Compressor efficiency above .... as far as possible. (Mycom and Filters)	**CG14**	Technical	**MEH**
CAT16	CO2 trans-Critical heat pumps (Mayekawa)	**CG10**	Other (relatively new, no regional installs)	**MW**
CAT17	ECON development entities	**CG9**	Other (political and lack of centralization)	**PL**
CAT18	Food chemical feedback sensor to control process heating, such as balancing time	**CG4**	Other (awareness)	**RP**

Commercially Available Technology R&D Code	Commercially Available Technology R&D	Linked to Commercially Available Technology	Where is the research?	By
CATRD1	Logix refrigeration controls and Cascade energy intellifrost project	CAT9	Logix offices, Cascade Offices, Henningsen cold storage	PL
CATRD2	Provide funding for demonstration. Demos need to involve manufacturers, consultants, vendors, installers and end users	All existing technologies		PL
CATRD3	Standardized industrial compressor ratings are needed	CAT15		MW

Commercially Unavailable Technology	Commercially Unavailable Technology	Linked to Capability Gap	By
CUT6	Coils that do not frost up - someway to eliminate the frosting.	CG1	PL
CUT7	Binary fluid ejector heat pump (Thermally driven)	CG9, CG10	BW
CUT8	Develop air and refrigerant compressors that are as close as to 100% Compressed gas energy and virtually no heat	CG14	MEH
CUT9	Doors that seal while open	CG8	PL
CUT10	Regulating relaxation-zoning	CG9	PL
CUT11	Optimal chemical or working field	CG2	PL
CUT12	Liquids that can be used for direct (immersive) freezing of product-to eliminate air flow and fan energy use	CG15	MW

Commercially Unavailable Technology R&D Code	Commercially Unavailable Technology R&D	Linked to Commercially Unavailable Technology	Where is the research?	By
CUTRD1	Development of alternative coil designs-self defrosting	CUT6		PL
CUTRD2	Explore alternative methods of getting and out of freezers	CUT9		PL
CUTRD3	Regulatory relaxion at high levels	CUT10		PL
CUTRD4	Develop alternative working fluids for refrigerants and coolants	CUT11		PL
CUTRD5	Develop a liquid for immersive cooling of food products (e.g. vegetables)	CUT12		MW

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Infrastructure Technologies

Capability Gap Code	Capability Gap	Linked to Driver	By
CG1	Lack of energy efficiency element in trainings (i.e. lean, productivity)	D1, B5, EG5, B2, B1, B6, B7, B8, MD17, MD10, MD11	SS
CG2	Lack of industry and plant goals and implementation plans. Lack of management awareness and commitment. (ISO 50001)	B5, MD10, MD8, B8, MD16, MD17	PB
CG3	Better efficacy of lighting for cold storage for food	B8, EG5, T13	RP
CG4	Lack of energy management systems for industry benchmarking (KPI, dashboard)	MD15, Md10, MD16, B6, B5, B1, EG1	GW
CG5	More focus on HVAC in plants-Learn from commercial	B1, B8, T1, T5	MP
CG6	Lack of clarity and documentation for sustainability (i.e. life cycle cost analysis, embeddedenergy) Prep for green supply	EG1, EG3, EG4, MD10, MD12, B2, B4	PB
CG7	Lack of inclusion of embedded energy cost of water supply and waste water treatment decisions, better water	EG4, MD10, MD7, MD15, PR8, MD13	GW
CG8	Lack of workforce development; better academic + trade school curriculum, attracting more students into industry	MD9, MD10, MD12, MD16, B6	GW
CG9	Lack of smart tracability info systems from farm to consumers	MD10, MD11, MD15, MD17, PR1, PR11, PR8, MD14, B2	QL
CG10	Lack of data acquisition and analysis, tracking sustainability of food lines	MD10, MD11, MD15, MD17, PR1, PR11, PR8, MD14, B2	GW

Commercially Available Technology Code	Commercially Available Technology	Linked to Capability Gap	Barrier Type	By
CAT1	LED, occupancy controls	CG3	Other (cost effectiveness, knowledge, continued	RP
CAT2	More widespread knowledge/awareness of heat load in	CG3	Other (not wide	RP
CAT3	More widespread implement CEI (or ISO 50001) in	CG2	Other(lack of	SS
CAT4	Implement K-12, community college + university programs on energy basics	CG8	Other (funding to add new	MP
CAT5	RETA (CEV) not implemented formally. NEEA work with	CG1	Other (training	SS
CAT6	ETO-ROC widespread adoption by providers (refrigeration operations training)	CG1	Other (no widespread	GW
CAT7	Energy awareness training focused on industrial energy use	CG1	Other	SS
CAT8	Improved control systems	CG5	Technical	MP
CAT9	Real-time energy monitoring hardware-main and sub	CG4	Other (high cost,	GW
CAT10	Training for operations and maintenance practices	CG5	Other (workforce	GW
CAT11	Integration of flow meters or other water use data into energy information and monitoring systems	CG4, CG7	Other (high cost, awareness, lack	PB

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CAT12	Establish standards of service and comfort	**CG5**	Other	**SS**
CAT13	Data compilation analysis and presentation software focused on industrial (benchmarking, dashboards and KPIs)	**CG4**	Other (few vendors, high cost, few industrial	**MP**
CAT14	Training on EIS intrepretation and use	**CG4**	Other (No standard software, not	**GW**
CAT15	Some information available on embedded energy in water	**CG7**	Other (lack of information on	**SS**
CAT16	Case studies, publically available on overall life cycle energy assessment in food processing	**CG6**	Other (fundings to do the study)	**MP**
CAT17	Auto ID systems and bio sensor technologies	**CG9, CG10**	Other (cost	**QL**

Commercially Available Technology R&D Code	Commercially Available Technology R&D	Linked to Commercially Available Technology	Where is the research?	By
CATRD1	Better controls, cost effective for refrigerated lighting	**CAT1**	EPRI	**RP**
CATRD2	Reach out to industry suppliers for case studies. Have	**CAT1**	Digital Lumens	**SS**
CATRD3	Development of delivery mechanisms for C&I, ISO 50001	**CAT3**	ITP, NEEA	**SS**
CATRD4	Outreach, education, directed courses and workshops	**CAT4, CAT2, CAT12**	NWFPA, OSU	**RP**
CATRD5	Market survey, industrial challenge upstream	**CAT9**	BPA, NEEA	**SS**
CATRD6	Identify EMCS with water flow monitoring, survey industry	**CAT 11**		**GW**
CATRD7	Templates for sustainability metrics, KPIs, monitoring,	**CAT16**	NWFPA	**PB**

Commercially Unavailable Technology	Commercially Unavailable Technology	Linked to Capability Gap	By
CUT1	Fiber optics training	**CG3**	**GW**
CUT2	More standardized templates for documentation of sustainability for green supply chain and other inspections	**CG6**	**RP**
CUT3	Order of magnitude price reduction in efficient lighting	**CG3**	**GW**
CUT4	Electro luminiscent paint	**CG3**	**SS**
CUT5	Order of magnitude improvement in lighting system effacy	**CG3**	**SS**
CUT6	Reliable benchmarks for food processing industry	**CG4**	**PB**
CUT7	Self correcting energy management systems based on known inputs eg. Seasonal variations in defrost	**CG4**	**MP**
CUT8	Product quality attribute and composition ensors that control thermal or mechanical processes e. monitor	**CG4**	**PB**
CUT9	Individualized cubicle environment (on site/off site)	**CG5**	**MP**
CUT10	Auto ID (smart) enable electricity management system for	**CG4**	**QL**
CUT11	Smart tracebility system from farm to consumer	**CG9, CG10**	**QL**
CUT12	No systems available off the shelf for industrial energy	**CG4**	**PB**

Northwest Energy Efficiency Technology Roadmap Portfolio
Food Processing Industry Workshop, Aug. 18, 2011

Commercially Unavailable Technology R&D Code	Commercially Unavailable Technology R&D	Linked to Commercially Unavailable Technology	Where is the research?	By
CUTRD1	Continued research	CUT1, CUT3, CUT4, CUT5	GAP	SS
CUTRD2	Development of benchmark and standards	CUT6	NWFPA, EPA,	DB
CUTRD3		CUT10	GAP	
CUTRD4	Develop industrial software systems	CUT12	GAP	PB
CUTRD5	Need to define smart tracebility information system, the components, the governance body and hardware/software	CUT11	OSU Food Innovation	QL

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Mechanical Technologies

Capability Gap Code	Capability Gap	Linked to Driver	By
CG1	Need smart motor that work with smart grid	PR7	MAR
CG2	Applied technologies from other industries	EG5	JE
CG3	Integrated industrial process optimization in use of mechanical	EG5, MD10, MD16, B1	QL
CG4	Low cost, easy to install sensors and controls are needed	MD1	MAR
CG5	Need dedicated industrial staff working on energy efficiency at plant level	B5, EG5, MD1	JE/MR/DS
CG6	Need training education for use of mechanical equipment	B5, B6, B8	JE
CG7	Need consultants that are experienced with energy management or continous energy improvement	B8, B5, EG5	JE/MR
CG8	Need extending storage time for raw product (use of mechanical equipment)	PR7, EG4, MD1	JE/MR
CG9	Need smart battery charging for vehicles mechanical non essential	PR7, PR1	JE/MR
CG10	Need leak detection tools and meters	MD1, B2	DS
CG11	Need fan wall application for air movement to SUPPMT product cooling	T13	MAR

Commercially Available Technology Code	Commercially Available Technology	Linked to Capability Gap	Barrier Type	By
CAT1	Separations (product from waste, water from product) with low energy	EG5	Other (need to demonstrate in food processing industry)	GBP
CAT2	DOE, Hydraulics Institute Compressed Air Challenge, NEEA	CG6	Other (lack of participation)	JE
CAT3	Laser food processing (marker and micro perferations)	CG2	Technical	QL
CAT4	Industrial assessment centers, Lean training	CG3	Other (time availability)	DS
CAT5	Some industrial EE program administrators provide, but PNW lacks	CG5	Other (some ee administrations do not provide)	JE
CAT6	Premium efficient motors	CG6	Other (limited adoption in dedicated lines because of limited	MAR

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CAT7	Efficient gear boxes	**CG6**	Other (limited adoption in dedicated lines because of limited opportunity for change)	**MAR**
CAT8	Energy management software; metering equipment. i.e. Nortwright, eSight	**CG7**	Other (Not designed for industrial market)	**MAR**
CAT9	Variable frequency drive	**CG6**	Other (limited adoption in dedicated lines because of limited opportunity for change)	**MAR**
CAT10	Fan Wall	**CG11**	Technical	**MAR**
CAT11	Compressed air leak management practices, products services	**CG10**	Technical	**MAR**

Commercially Available Technology R&D Code	Commercially Available Technology R&D	Linked to Commercially Available Technology	Where is the research?	By
CATRD1	Demonstrations at selected processes where separations are energy intensive and costly and where seperatial steam can be recycled.	**CAT1**		**GBP**
CATRD2	Test certification program (RETA)	**CAT2, CAT3**	NEEA	**MAR**
CATRD3	Test cash incentive for training	**CAT2**	Idaho Power	**MAR**
CATRD4	Preliminary study how laser perforation of blueberry can improve fruit infusion with more yield and better quality	**CAT3**	OSU Food Innovation Center	**QL**
CATRD5	Strategic Energy Management	**CAT4, CAT5, CAT6, CAT7, CAT8, CAT9**	BPA, ETO, NEEA, NWFPA	**MAR**
CATRD6	Investigate new products that may reduce the effort required for leak detect and fix	**CAT11**	GAP	**MAR**
CATRD7	Understand the fan wall technology if its applicable to industry	**CAT10**		**GBP**

Commercially Unavailable Technology Code	Commercially Unavailable Technology	Linked to Capability Gap	By
CUT1	Motor responds to signals from grid. Energy eficiency vs Surge management	CG1	MAR
CUT2	Advanced conveyance technology (belts, rollers etc)	EG5, PR7, MD1	GBP
CUT3	Non invansive sensors for flow/pressure	CG4, CG10	MAR
CUT4	Raw product storage alternative to refrigeration and freezing	CG8	DOR
CUT5	Smart chargers that respond to demand response signal-balance with process requirements	CG9	MAR

Commercially Unavailable Technology R&D Code	Commercially Unavailable Technology R&D	Linked to Commercially Unavailable Technology	Where is the research?	By
CUTRD1		CUT1	GAP	MAR
CUTRD2		CUT2	GAP	MAR
CUTRD3		CUT3	GAP	MAR
CUTRD4		CUT4	GAP	MAR
CUTRD5		CUT5	GAP	MAR

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Appendix A7:
Combined Heat and Power Workshop (Dec. 15, 2011)

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Agenda

Industrial CHP Technology Roadmap
Dec. 15, 2011

Purpose of Workshop: Provide technology experts engaged in industrial applications of combined heat and power with a structured workshop intended to produce info needed for the drafting of a "living" research agenda that identifies and prioritizes high-value, energy efficiency research and development topics for pursuit by pertinent Northwest stakeholders.

Thursday, Dec. 15, 2011

8:00 am — Welcome and Overview of Workshop Goals and Process
- **Joshua Binus**, *Bonneville Power Administration*

8:30 am — Task 1: Revise and Identify Drivers/Challenges

FOCUS QUESTION #1: What drivers are expected to impact the use and/or development of CHP products and services over the next 20 years in the industrial sector?

9:15 am — Task 2: Identify & Negotiate CHP Application/Technology Categories
- Roadmaps will be developed for each of these categories
- Divide into sub-groups

9:45 am — Break

10:00 am — Task 3: Identify Capability Gaps Needed to Address Drivers
- Make sure to link Capability Gaps to appropriate Drivers

FOCUS QUESTION #2: What are the required capabilities (products and services) needed in order to address the identified drivers?

11:30 am — Working Lunch – Finish Identifying Capability Gaps (If completed, begin working on next task.)

12:00 pm — Task 4: Identify Technologies Needed to Address Capability Gaps
- Make sure to link Technologies to Capability Gaps
- Articulate whether each technology is "Commercially Available" or "Not Commercially Available"

FOCUS QUESTION #3:
What are the technological solutions which can be applied to enable currently unavailable capabilities needed over the next 20 years?

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1:30 pm	Task 5: Identify Existing R&D Programs; Identify R&D Gaps ► Make sure to link R&D Programs/Gaps to specific Technology(ies) Needed
	FOCUS QUESTIONS #4 and #5: What/where are the existing R&D programs which are addressing the technology gaps discovered in Question #3. What new R&D programs are needed to address technology gaps?
2:15 pm	Break
2:30 pm	Sub-Group Presentations & Group Discussion (Cross Fertilization)
4:30 pm	Review Process for Prioritization of R&D Programs [Post-Workshop]
5:00 pm	Adjourn

Northwest EE Tech Roadmap Portfolio
Combined Heat and Power Technology Roadmap Workshop

BPA Headquarters, Room 122
Dec. 15, 2011, 8:00 a.m. to 5:00 p.m. [FINAL]

Attendees:

1. Joshua Binus, BPA (Facilitator)
2. Todd Amundson, BPA
3. Jennifer Eskil, BPA
4. James V. Hillegas, BPA
5. Jisun Kim, BPA
6. Steve Knudsen, BPA
7. Chris Milan, BPA
8. Whitney Colella (Pacific Northwest National Laboratory)
9. Chuck Collins (Cascade Power Group) [from 9:00 to 11:00 a.m.]
10. Ken Corum (Northwest Power and Conservation Council)
11. Mark Fuchs (Washington State Dept. of Ecology)
12. Mike Henderson (ConAgra Foods)
13. Graham Parker (Pacific Northwest National Laboratory)
14. Thomas Reddoch (Electric Power Research Institute Inc)
15. Carolyn Roos (Washington State University)
16. Dave Sjoding (Washington State University)
17. John Thornton (Northwest Food Processors Association)
18. Juliana Williams (Cascade Power Group) [from 9:00 to 11:00 a.m.]
19. Mark Lynn (Simplot)
20. Bill Wilson (Washington State University Extension Energy Program)
21. Eric Simpkins (fuel cell industry)
22. Chris McCalib (Lakehaven (WA) Utility District)

Minutes by James V. Hillegas (BPA)

8:23 Call to Order. Opening remarks from Joshua Binus, including overview of agenda and what to expect [see slide deck]. Introductions of attendees.

9:08 Task 1.

9:25 Task 2.

Sjoding explains the four categories identified in Slide 5, which initiates a discussion about how best to categorize applications and technologies and thereby divide attendees into work groups. Sjoding suggests folding-in the "Applying CHP" category with one of the other three categories to create three working groups.

Roos suggests that the topics be categorized into three groupings: 1) Production; 2) Delivery/End Use; 3) Resources (fuel inputs). Collins agrees with this three-tiered categorization because it correlates with his experience of CHP policy issues and discussions.

Parker's one caveat is that fuel resource considerations cross into production technologies, because considerations about fuel supply and sourcing are the same regardless of what technology is used.

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Henderson asks if the group small enough that we don't need to break into subgroups at all?

Binus responds that, no, having all 16-17 attendees in one group will be too chaotic. However, he suggests that attendees could break into two groups, one focusing on production and one focusing on delivery/end use, and both groups could address fuel resources. His concern is that someone might be working in the Resources group even though they have expertise in one or both of the other topic areas, so this expertise will not be part of the discussion. If both groups address Resources, at the end we'll combine both groups' input on this topic area. Also, at end of the day there will be an opportunity during the Sub-Group Presentations for everyone to hear a synopsis of the other groups' progress, and contribute additional information, if required.

9:45 Break

10:05 Task 3

12:00 Task 4

1:00 Task 5

2:30 Sub-Group Presentations & Group Discussion

Sjoding provides the presentation for the Production & Resources Sub-Group:

The first research area involves recovering waste heat from corrosive and fouling exhausts. This could include developing materials coatings for various toxic gases that will allow treatment plants to use dirty gases—gases containing siloxanes, fluorines, sulfuric acid, etc.—and corrosive gases. Research comes down to working with companies to apply coating technologies to solve the issues of dirty biogas. Similarly, we also need improved materials or coatings for sensors in these environments, so that they are not fouled or corroded. Some examples of commercially unavailable technologies in these areas would be improved materials coatings, "smart" soot blowers, and pulse detonators at smaller scales that would provide sonic pulses to jar-off the fouling that coats equipment.

Another important Capability Gap involves issues of economically feasible, scaled technology. For example, scaling-down heat recovery technology or pre-packaging recovery systems that can be plugged-in at smaller scales. This would be a game-changer if we could economically get critical technologies at smaller scales.

Stirling engine piston problems are also an issue. The research needs here are: materials testing for Stirling pistons; re-design of the piston rings; and redesign of the thermocouples and probes. It appears that research on these issues at the Stirling Biopower company is hung-up right now.

We also need systems that provide heat recovery from low to moderate waste heat. The Rankine cycle, Kalina Cycle®, and binary mechanical vapor compression concepts are known, but applicable technologies are not commercially available. A current technical barrier is that there is a great need for demonstrated cost-effective technologies in this area (including advanced heat pumps), the first production models and accompanying information sheets to be disseminated widely. A big problem is getting "model 001" of these systems into the marketplace, getting a company willing to work on that. This is a risk to companies that might want to do this work. Need to work on the research and development side to keep costs down.

Regarding the direct power conversion from heat, we need to find out if we can get heat out of the infrared spectrum. For example, one commercially unavailable technology is thermal equivalent photovoltaic cells providing heat recovery modules that generate electrical power directly from the waste heat stream. It seems as though some related research is going on, but this points out what I find to be another big problem, which is that only part of a technology is being funded, but some important parts are not funded, for example, providing pilot testing or scalability.

There are also a host of issues related to stranded assets—where the host or user for the heat generated from a CHP installation has moved away or gone out of business. How do we handle this? There needs to be salvage value to a CHP installation. What if we were to work in a more modular fashion, so that we could move to new host? Another way is less a research and development issue and more about education – where else might process heat be used in an industrial park, for example? One good instance of this is Biomass One in White City, Oregon (http://www.biomassone.com/), which lost its host for making CHP, but within a half-mile inside the industrial park there were other potential users. This is part of the education and training that needs to happen, so that producers are aware that their CHP can go to other users, and users are aware that there are CHP options not too far away.

The high cost of fuel cell energy per kW is a Capability Gap. We need increased production and capacity to get the costs down, and this requires independent collection and analysis of performance data. Is the product working the way the company says it is?

Colella: A useful presentation on this topic is listed at the Pacific Northwest National Laboratory website under "Video Presentations" (http://tinyurl.com/3n5ykxu). The presentation is a twenty-minute streaming video presentation on independent analysis and performance verification of one manufacturer's CHP fuel cell systems.

Sjoding: We also need good modeling in the research and development area. Also need to find ways to integrate fuel cells with a renewable gas supply, and to figure out if this makes economic sense. Fuel cells require high-quality gases (more so than Stirling engines), so if biogases are used, these dirty gases require additional purification and scrubbing.

Can CHP thermal and electrical power be stored economically, and be dispatchable? Both intermittently and in the context of base power, can you play off thermal and power needs with one another? The Kotzebue Electric Association in Alaska (http://www.kea.coop/articles/keeping-tabs-on-energy-use/) uses the utility districts' energy heat as a regulator, in combination with smart grid monitors at the residential level, to regulate thermal load needs against electric load needs.

We also need plug-and-play interconnection systems and standards in this area, like the Interstate Renewable Energy Council (IREC, http://irecusa.org/). Right now, systems and standards vary from state to state, so there's no standard to grade against. This plug-and-play approach will require improving interconnections and establishing and developing standards; this plug-and-play ability needs to be in the grid system as well. An important piece of work.

Another kind of odd Capability Gap has to do with the U.S. Environmental Protection Agency (EPA) and air quality standards. Currently, it's possible to get a type certification for a gas engine, but how many engines have been so certified? None. Where are the barriers? Since these systems have not been type certified, the developer of the technology is then saddled with the initial costs of certification and then with the costs of re-certifying generator sets every year.

This brings up a more generic issue: When developers have an unproven technology, they need to go through the data gathering and analysis stages to find out if it's working the way it's supposed to, if its performance is verified. We need an independent data collection and verification entity.

Colella: National labs, such as Pacific Northwest National Laboratory (PNNL, http://www.pnl.gov/), can serve this purpose. National labs are typically organized so as to not have any vested interest in any one technology or manufacturer. The labs can be used as a resource for independent, expert review.

Corum: I should have asked about the Capability Gap before, regarding the technology that has not been type certified—what is the research topic associated with this gap?

Sjoding: We would work with the manufacturers to get at a type certification process. Work with the manufacturers to get the data, work with the EPA to ensure they get their data needs met, and then ensure communication between these entities.

Corum: Companies haven't done so to date?

Binus: Is this a vendor service?

Thornton: Is it almost more of a certification process?

Sjoding: Yes, this is a certification process, and the costs of the process are being shunted to the developer. There is a cost upfront to get the permit, then a cost every year thereafter.

Corum: Having this process in place would be more attractive to developers in the future.

Sjoding: The next two that I've got are linked. Ask yourself, do we have a cadre of engineers that can do CHP feasibility all the way through to design & development? I've come across a shocking number of large firms in the region that don't have this kind of expertise. Within industrial technology systems, there is a test, and then you're U.S. Department of Energy (DOE) certified, but this does not exist for CHP. It's a set of homework that needs to be done to educate and mature engineering firms in the Pacific Northwest. We are not as far along as the Midwest and other areas. With no test, there's no directory of certified engineers to refer to. This is a combination of training, certification, testing, and then registering these qualified engineers in a directory illustrating their competence.

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Now we're back to dirty biogas. We need to know whether systems can handle dirty gas, like Stirling engines, or if one has to have to have a scrubbing technology that is cheap enough for smaller systems to use. One example is Cedar Hills landfill in King County, Washington. This facility is big enough to scrub methane to remove CO2, hydrogen sulfide and other gases, which they then compress, and they finally have enough biogas to use. This is a big enough system. Get below this size, however, and there will be a struggle to make it worthwhile. We need a set of companies in the Stirling engine area in the market, *that* would be wonderful.

Colella: As shown by this presentation, there was also a CHP fuel cell system installed at this site in King County, Washington, running off of biogas: www.epa.gov/chp/documents/wbnr111909_dvh_presentation.pdf (slide 15). This was a hallmark, cutting-edge installation. (According to the presentation, maintenance costs proved too high with the CHP fuel cell system running on biogas fuel. CHP fuel cell systems running off of natural gas in California have not had this problem.) R&D may be needed to reduce maintenance costs for biogas-fueled fuel cell systems.

Sjoding: Moving on to the Resources Capability Gaps: Medium and high solids anaerobic digestion produces biogas (15% or 15-20%, respectively). Food processing industry and post-consumer source separation for food waste (a number of cities do this) produce biogas this way. However, these facilities produce odor, so what is needed are a number of digesters to do this. This is a technology that is in the "valley of death" – it is in the first pre-commercial scale build-up level, but there is no funding available to continue the testing and analysis.

Colella: Additional funding appears to be needed on R&D related to purifying food processing industry waste for biogas creation, and at a high enough purity level for fuel cells.

Sjoding: We also need to find better biomass drying and improved CHP systems to handle wet biomass. Moisture is the Achilles heel of CHP waste. We need to find ways to dry it without the system catching fire. There are different technical pathways. What if we did a microwave approach to getting moister out? There is a company in the U.K. doing this work—Rotawave (http://rotawave.com/)—but no one in the U.S. is doing this work. Who's going to be the first here? Considering only the forest products industry in the Pacific Northwest, the Rotawave technology is probably suitable.

The other question is, how hot a temperature can we use to burn these materials at? If we go too hot, we start to melt the burner. Existing companies won't develop burners that can handle higher temperatures. There is a project at Springville, Washington [Correct location?], that they are building that is such a high-temperature system, but we don't know the specifications. This was first tried at a mill in Morton, Washington, but the temperature was too high, and they used a different approach

Another need is for thermally-driven absorption chiller systems that are cold enough for chilling, and for optimal thermal integration. This would be helpful for the food processing industry in particular.

Colella: Most of the absorption chiller systems now in use are less efficient, about 0.7 units of cooling power output for every 1 unit of heat input. This performance unit is referred to as the coefficient of performance (COP). By contrast, most electric chillers will produce 2 to 6 units of cooling power output per unit of electricity input. Most of these absorption chillers with a COP of 0.7 are single effect chillers, so it would be helpful to look at double and triple effect chillers, which have higher COPs. It would also be good to look at ammonia-water absorption chillers, which can produce cold enough output to make ice. It would also be helpful to model the thermodynamics of the absorption chillers themselves as well as their thermal integration with CHP generators. A ripe R&D area is the optimal thermal integration of heat streams between the absorption chiller and the heat source (the CHP generator). There are also low temperature heat streams coming out of the absorption chiller itself, which could be used for pre-heating. An additional important R&D area is integrating this heat into a production facility itself, which has its own heat needs.

Sjoding : A lot of work here, that's it.

Binus: Any comments or questions?

Roos: One thing, just to clarify. Of the two Capability Gaps you said were related to handling dirty gases, the first one was dealing more with waste heat from industrial processes, the second one with handling dirty gases in general.

[Break]

Parker presents the findings of the Sub-Group on the Delivery and Resources:

I think we're going to find that a lot of what we did in this group was touched on by Sjoding .

Regarding Capability Gap 16, the idea of CHP systems that store power, store heat, seems to be pretty intriguing but the technology is not developed yet. It has been done for other industries and applications, but not for CHP. This was touched on by other group, so I'm not going to touch on that.

We've got, generally, CHP systems that are done on an as-engineered basis for a specific application, which means these systems are not generally transferrable. They're not modular. Our group was looking at how to get a packaged approach to CHP systems to bring them into a plant, and they're designed broadly enough, that the CHP system could be changed in accordance with plant changes or closures; or the system could be relocated to a similar plant, somewhere else, etc. There's a lot of money going in to these systems, and it seems a shame to waste the investment because the system can't be modified or relocated. My guess is that the Albany pulp and paper plant had a CHP system that is now wasted with the mill's closure.

Reddoch: That's pretty similar to something the other group did, to address Capability Gap 7.

Knudson: Another dimension is, when you're trying to get a new project, a bank is going to be looking at the finance plan, and if they don't see a salvage value for the project, they might not finance it.

Corum: Is there very much salvage value for a typical CHP bundle?

Wilson: On the electricity-generating side, yes, but on the product side, not really.

Sjoding : During the dismantling and parting-out of old mills, there is a market, but some of the challenge for economic development is to keep the mills from being parted-out for salvage value. One example is the Kimberly Clark mill, with negotiations for sale ongoing. There is a real estate firm in Eugene that sells mills in their entirety as components to firms in China.

Corum: Would 30 or 40 percent salvage value be a valid rough estimate?

Roos: You can take a steam turbine and reload it, like Grays Harbor.

Thornton: Yes, but there is an expense.

Corum: Maybe the lesson here is that the value and utility of a CHP unit could be augmented by packaging the system so it can be moved?

Wilson: Large systems are inherently built-up from individual components, and these have sale value by being parted- out.

McCalib: We had a project that had brand new components and was built but never used. When the project fell through and the components were parted –out, through legal processes the as-new sale price was only 15-20 percent of the original cost, even though the system hadn't ever been used.

Colella: 10% of the original project expenditure is a typical salvage value used in corporate finance.

Simpkins: What are the economic drivers for this?

Sjoding : There are many layers on the economic front.

[Note: Capability Gaps 20 and 21 links to Capability Gap 5]

Parker: There is a need to link hybrid system to smart inverters. This is available for some technologies, but not CHP. This is really an application problem—the need to apply technology from one application to another. [Note: Capability Gaps 23 and 37 link to Capability Gap 8]

Regarding high-efficiency thermal storage technologies, there are phase change materials being developed for insulation, why not for storage as well? [Note: pertains to Capability Gaps 24 and 25]

Regarding low-grade waste heat, there is a need to find a way to utilize this best. It could be in some absorption technology, or micro technology for heat exchange. We know this is going on in some areas: there are silos of excellence, but we need better communication about these systems. [Note: Capability Gaps 26, 19, and 17 link to Capability Gap 4]

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Our next research and development area addressed the incapability of good engineers to do good thermal measures and plans, both cost effectively and more broadly. This is an area that we identified early in group discussion. In order to design a new CHP system, we need to understand the full process and complexity – if not, the design is not modular, and as things change the CHP system is not able to change also. Part of the issue here is that we never have enough data.

Colella: In general, there is a lack of measured data on both the temperature and quantity of heat demanded from buildings over time. While electricity meters at the building level often exist, the equivalent real-time measurement of heat over time is often lacking at the building. The quantity of heat demand is sometimes back-derived from fuel consumption data. However, rarely is the temperature of this heat demand either recorded through direct measurement or able to be back-derived. This need for heat demand data (both temperature and quantity) highlights an important R&D area and technology gap area.

Wilson: I agree, it's a lack of good data, because very often the data has to be obtained indirectly, which means that engineers might not have direct experience with the system. On the other hand, an engineer has to have his head pretty deeply into a project in order to get the amount and quality of data necessary.

Henderson: It's not only having the meter to collect the data, it's also an issue of maintaining the large amounts of data. There are different areas of shortcomings here.

Parker: Obviously, when you design the plant, before you put it into operation you've already made changes.

Wilson: A lot of people know the ins and outs but not the in-betweens.

Parker: Let's talk about electric storage specifically for CHP operations. One can send electricity out to grid, but sometimes that does not work, so what to do next? [Note: Capability Gap 30 links to Capability Gap 7]

Knudson: We didn't talk about this issue directly, but we talked about dispatchable load, and how to shape CHP energy in a way for utilities to use it.

Parker: We also looked at smart technology. Right now we have a lot of smart control potential technology out there, mostly tied to residential applications. Lots of devices and software, but there still are gaps for CHP in process industries. There is almost no work being done beyond typical demand response technologies, especially smart software. This even goes as deep as the plant itself: how do we make the machines smart and the CHP smart?

Sjoding : We might want to talk to Merle Smith. [Affiliation?]

Parker: It's in its infancy, which is a good start, but researchers also should consider integrating the needs of industry with this research. There's a lot that could be done. I'm not a cynic, but sometimes these things are running ahead of what industry's interest is, and I want to be sure that DOE isn't running ahead of what Industry is interested in.

Ok, on Resources side, there will be many similarities. One of them is work needed on biomass gasifiers to make them work and be competitive with CHP applications.

Henderson: Would that include enough heat recovery off the gasification process?

Parker: Yes, I think we captured it here. Alright, now we start to look at biomass, or anything that has to do with transporting fuel from point A to point B. In all the studies I've seen, it's about 50, 60 miles of travel between the source of the biomass and the point of processing the biomass before these costs become prohibitive. I know there are a lot of studies that have been done, but there are studies that need to be done on optimization. I recall when they were building a runway at Atlanta, they built a transport system for fill dirt that consisted of a five mile conveyor belt; this was cheaper than trucking the fill. People should apply this kind of thinking into biomass transportation to CHP generators.

Roos: Yes, the mining industry also uses conveyor belts because it's a great substitute for gas and diesel. It gets emissions down to almost zero.

Parker: I have seen that in action at mining operations. On the other hand, one Nevada operation also slurried coal and transported it, but this is not good.

Roos: Another good way to transport is compaction.

Parker: So, one could pre-process the biomass material, and then put it on a conveyor belt.

Lynn: We use these technologies, and a conveyor belt is more efficient, but also ten times the maintenance costs of the long conveyor.

Parker: Here's another Capability Gap, and I'm doing this, Binus, because you said you wanted us to think twenty years ahead: Can anyone predict the price of natural gas in twenty years?

Sjoding : The Northwest Power and Conservation Council (NPCC) just put out their projection of well head prices out to 2030, isn't hat official?

Corum: The way we use it is the whole probability distribution of potential prices around that projection.

[Corum added the following points of clarification to his comment above upon review of the first draft of the minutes: "The way we use the projection of natural gas prices (and several other variables) is to sample from an estimated probability distribution to make up a set of 750 futures that we test resource portfolios against. Put another way, we treat future natural gas prices as UNKNOWABLE, but likely to be in a range we've estimated. "]

Roos: The best way to manage that price is to have an alternative.

Parker: I included this because it's important to the industry, but it's hard to specify with accuracy much beyond three years.

On to another Capability Gap: Can you put a CHP or fuel cell system together that can run on multiple fuels, and is smart enough to run on different fuels and also draw energy from or put electricity on the grid? The multiple fuel use wouldn't be infinite, but perhaps it could be up to three or so fuels.

Colella: Stationary fuel cell systems can be engineered to run on multiple fuels within the same device. Stationary fuel cell systems have been demonstrated to run on any of these fuels: natural gas, methane, hydrogen, liquid petroleum gas (LPG), landfill gas, biogas, and anaerobic digester gas (ADG). Most commonly, stationary fuel cell systems use natural gas for fuel. When ADG is used, the digester gas is typically mixed with natural gas so as to provide the fuel cell system with a consistent gas composition over time.

Parker: Right, this is not something that one sits down and decides, but a system that gets price signals and makes real-time decisions.

The last Capability Gap we have is to optimize the system.

Roos: Is this a modeling issue?

Parker: It's more than modeling. It's like a smart grid for fuel cells. Your power and heat are going to be different based on fuel.

McCalib: Why would you ever want to switch to a fuel source that is not renewable or available at your facility? At our facility we have a reliable supply of fuel.

Parker: Is the fuel at your facility 100% reliable?

McCalib: Putting costs into a system by building a multiple-fuel CHP system where fuel source is almost guaranteed is not an advisable economic decision.

Knudson: Building such a system could be economical if there were fuel switching available, depending on fuel prices.

Fuchs: Is there such a thing as a 100% reliable fuel? My conclusion out of this is that we get to choose; we chose where we're at now, we can make a choice about the future, or we can create economic models and lots of questions about whether there's only hydropower or natural gas as a choice, for example. I'm not saying these are not good things, but it seems to me that our big challenge is that we have forgotten how to create industrial capacity.

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Roos: Sometimes, even though the resource is free, the costs of capturing the resource are more than the resource is worth.

Henderson: Renewable biogas has costs, such as investments in infrastructure.

McCalib: The cost inherent in using prime movers for pipeline quality natural gas is not feasible for us, unless there are some large economic changes. King County does process their gas into pipeline quality natural gas.

Wilson: I think in your case it's more about waste heat use, rather than cogeneration.

Knudson: King County is selling their natural gas, but they wouldn't be if they could generate electricity and sell it back into the system.

Henderson: If CHP could be labeled a renewable source of power, then such examples could be sold as renewable. This is a policy issue. If things were different, then King County's returns would be different.

McCalib: A lot of the time the public entity is not legally able to take advantage of profit situations – for example, to turn around and make money from the digester gas selling back into the grid.

JB: Any more comments specifically for the minutes? No, let's move on.

4:15 p.m. Workshop adjourned

Northwest Energy Efficiency Technology Roadmap Portfolio
Combined Heat Power Workshop, Dec. 15, 2011
(with stakeholder revisions of Jan.-Feb, 2012)

CHP Roadmap Drivers

No.	Driver Category	Driver Code	Description
1	Environmental & Global Drivers	D1	Climate change
2	Environmental & Global Drivers	D2	Peak oil
3	Environmental & Global Drivers	D3	Energy security;
4	Environmental & Global Drivers	D4	Water scarcity and cost, related health concerns
5	Environmental & Global Drivers	D5	Increasing cost and decreasing availability of raw materials
6	Environmental & Global Drivers	D6	Environmental impact of centralized power generation and transmission
7	Environmental & Global Drivers	D7	Fuel switching from combustion to electric
8	Environmental & Global Drivers	D8	Greater energy efficiency to reduce cost
9	Environmental & Global Drivers	D9	Reduce waste
10	Environmental & Global Drivers	D10	Organic recycling to recover energy, nutrients & carbon and address solid waste systems producing greater quantities of food and green waste
11	Environmental & Global Drivers	D11	Peak phosphorous
12	Environmental & Global Drivers	D12	Recover and reuse mineral N
13	Environmental & Global Drivers	D13	Quickly growing middle class in 3rd world – more demand for products
14	Environmental & Global Drivers	D14	Kyoto, global policies concerning energy
15	Environmental & Global Drivers	D15	Market penetration of intermittent renewable technology
16	Environmental & Global Drivers	D16	Environmental impact of new high voltage transmission
17	Environmental & Global Drivers	D17	Future reduction of carbon foot print
18	Environmental & Global Drivers	D18	Northwest continues to need new transmission construction. CHP may be able to relieve transmission system "bottlenecks"
19	Environmental & Global Drivers	D19	Energy security—Demand Response opportunity. Curtail
20	Environmental & Global Drivers	D20	Environmental permitting, CHP reduce emissions allow options to increase productions and operate within requirements or constraints of their
21	Market Drivers	D21	Uncertain future cost of electricity and gas
22	Market Drivers	D22	Proliferation of consumer electronics (increased plug loads)
23	Market Drivers	D23	More and cheaper products due to globalization of manufacturing – manufacturing and recycling modeling offshore
24	Market Drivers	D24	Increased adoption of LEED in building using CHP
25	Market Drivers	D25	Changes in types of industries in the Northwest
26	Market Drivers	D26	Market awareness (e.g., BPA E3T, utility demos and outreach)
27	Market Drivers	D27	Increased interest in and availability of plug-in hybrid and electric vehicles
28	Market Drivers	D28	Energy efficiency promoted through mainstream media
29	Market Drivers	D29	Competitive forces
30	Market Drivers	D30	Customer demand for sustainability and “green”
31	Market Drivers	D31	CHP systems require on-site thermal energy storage when exporting power to
32	Market Drivers	D32	Market need for clean / ALT. and low cost
33	Market Drivers	D33	Peak power generation (eg. Combined power and hydrogen: CHHP)
34	Market Drivers	D34	Increasing power costs
35	Market Drivers	D35	Competition – be as efficient as possible
36	Market Drivers	D36	Walmart – carbon foot print
37	Market Drivers	D37	Greening the market
38	Market Drivers	D38	Industrial self reliance – run a plant without outside power
39	Market Drivers	D39	Consumer pressure for more environmentally friendly products
40	Market Drivers	D40	Public perception – CHP can heal an environmental black eye
41	Market Drivers	D41	Maintain / improve competitive advantage
42	Market Drivers	D42	Reduce cost of production and energy intensity
43	Market Drivers	D43	Government incentives
44	Market Drivers	D44	~~Increasing~~ Financial value of storage is expected to increase
45	Market Drivers	D45	Corporate implementation of energy management - BPA ESI, ISO 50001, etc.
46	Market Drivers	D46	Regional and BPA / utility champions
47	Market Drivers	D47	Cost savings of EE
48	Market Drivers	D48	Need to be competitive with other producers/manufacturers
49	Market Drivers	D49	Uncertainty of quantity and quality of electricity provided
50	Market Drivers	D50	Shifts the control of electricity produced, distribution, use to within the industrial
51	Market Drivers	D51	Shorter product cycles (less certain thermal hosts for CHP)
52	Market Drivers	D52	Advancing use of distributed resources, including energy storage
53	Behavior / Social Drivers	D53	Employer pressure to increase productivity and lower cost of goods sold
54	Behavior / Social Drivers	D54	Consumer desire to be “green” and reduce embedded & used energy
55	Behavior / Social Drivers	D55	Consumer desire for comfort and aesthetics
56	Behavior / Social Drivers	D56	Changing demographics impacting purchasing choices and behavior

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CHP Roadmap Drivers

No.	Driver Category	Driver Code	Description
57	Behavior / Social Drivers	D57	Personal energy independence/interest in living off the grid
58	Behavior / Social Drivers	D58	Increased awareness of impact on kwh savings attributed to energy behavior
59	Behavior / Social Drivers	D59	Aging workforce, lack of trained workforce
60	Behavior / Social Drivers	D60	Pushback against over-regulation
61	Behavior / Social Drivers	D61	People like cool, new technologies such as solar PV
62	Behavior / Social Drivers	D62	People more "plugged in" electronically, digital information, social networking
63	Behavior / Social Drivers	D63	Lack of competitive CHP engineering
64	Behavior / Social Drivers	D64	Consumer expectation for “odor” mitigation
65	Behavior / Social Drivers	D65	Public perception – heal environmentally negative stereotypes
66	Behavior / Social Drivers	D66	NWS – NIMBY from public perspective
67	Behavior / Social Drivers	D67	Barrier – Lack of energy efficiency curriculum in engineering programs
68	Behavior / Social Drivers	D68	Consumer Choice – decision-making process by combining wants and desires with electricity pricing
69	Policy & Regulatory Drivers	D69	Carbon emissions penalties and/or incentives – CARB offsets in 2012
70	Policy & Regulatory Drivers	D70	Use of codes and standards to lock in efficiency gains (IS50001)
71	Policy & Regulatory Drivers	D71	Increasing budgets for emerging technology R&D
72	Policy & Regulatory Drivers	D72	American Clean Energy and Security Act of 2009
73	Policy & Regulatory Drivers	D73	Integrated resource planning
74	Policy & Regulatory Drivers	D74	Increased interest among legislators in efficiency and renewables – renewable portfolio standards
75	Policy & Regulatory Drivers	D75	Limits to existing transmission capacity
76	Policy & Regulatory Drivers	D76	Regulatory treatment of demand and efficiency programs including smart grid / demand response technologies
77	Policy & Regulatory Drivers	D77	Oregon and Washington law – CHP as efficiency
78	Policy & Regulatory Drivers	D78	EISA – waste heat registry
79	Policy & Regulatory Drivers	D79	Reduce landfill emissions, capture methane and produce energy
80	Policy & Regulatory Drivers	D80	Rate pressures and regulatory disallowances
81	Policy & Regulatory Drivers	D81	Carbon credit market / incentives
82	Policy & Regulatory Drivers	D82	Regional and BPA – utility champions
83	Policy & Regulatory Drivers	D83	Electricity pricing strategies
84	Technology Innovation Drivers	D84	Diffusion of common communication protocols into energy-consuming devices
85	Technology Innovation Drivers	D85	Integration of info, communication & entertainment devices
86	Technology Innovation Drivers	D86	Availability of cross-cutting, low-cost technology building blocks (i.e. wireless, ultra compact heat exchangers, advanced controls, ASDs)
87	Technology Innovation Drivers	D87	Availability and use of waste products as fuel for CHP production ~~Finding economic renewable power ower value in waste streams.~~
88	Technology Innovation Drivers	D88	Grid quality and consistency can be negatively ~~impacts ALT.~~ impacted by alternative power (CHP) ~~systems~~ system interconnection
89	Technology Innovation Drivers	D89	Availability of new technologies ~~such as dairy digesters~~ with ~~10~~ multiple
90	Technology Innovation Drivers	D90	Smart grid technologies across all sectors
91	Technology Innovation Drivers	D91	Smart Grid could make it easier to integrate distributed generation, including
92	Technology Innovation Drivers	D92	Major advances in heat pump technology
93	Technology Innovation Drivers	D93	~~Renewable power economic value in waste system~~ Renewable power generation creates income stream to support management of waste streams

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CHP Technology Roadmap Group: **CHP Production**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
1	CR, CMc	Capability Gaps	CG1	Develop materials coatings for contaminated waste heat to provide waste heat recovery from corrosive and fouling exhaust, i.e., siloxanes, waste water treatment facilities, sulfuric acid, gold smelting, fluorines, etc.	D93	~~D89~~ (delete link)				
2	CR	Capability Gaps	CG2	~~Scalability needs for smaller facilities with improved cost effectiveness.~~ Improved small-scale system cost effectiveness	smaller scale economic development					
3	CMc	Capability Gaps	CG3	Stirling engine piston problems	D93					
4	CR	Capability Gaps	CG4	Heat recovery from low and moderate temperature waste heat streams	D93	D8	D89			
5	SK	Capability Gaps	CG5	Co-dependency issue: How to integrate CHP? Stranded asset problem~~; lost host~~ upon loss of thermal host	D8	D51				
6	WC	Capability Gaps	CG6	Fuel cell high cost per kW; increased installed capacity and production volume; independent verification of performance	D32					
7	SK	Capability Gaps	CG7	Cost-effective storage for CHP-generated power; dispatchable power	D44					
8	BW	Capability Gaps	CG8	Need plug-and-play interconnection system and standards -- see Interstate Renewable Energy Council (IREC)	D88					
9	DS	Capability Gaps	CG9	Need U.S. EPA air quality type certification for biogas generator set equipment	D6					
10	TR	Capability Gaps	CG10	Unproven technologies; need fuel analysis, data, and independent verification	D93	D89				
11	BW	Capability Gaps	CG11	Direct electric power conversion from heat	D88	D93				
12	CR	Commercially Available Technology	CAT1	Organic Rankine cycle and Kalina Cycle®. ~~™ binary mechanical vapor compression.~~ Technical barrier: Not well known; need demonstraton project & case studies ~~Not well known, need first one in operation and accompanying information sheets~~	CG4					
13	SK	Commercially Available Technology	CAT2	CHP -- need designs with inherent high salvage value. Technical barrier: Modularity and portability; also, willingness of CHP generators to look beyond the fence for other potential thermal energy users	CG5					
14	WC	Commercially Available Technology	CAT3	Fuel cells. Technical barrier: Not economical; reliability issues; gas clean up	CG6					
15	SK	Commercially Available Technology	CAT4	Power storage and heat storage. Other barrier: Economies and lack of knowledge; configure CHP for utility rates and needs	CG7					
16	DS	Commercially Available Technology	CAT5	Biogas generator sets. Technical and other barrier: Need U.S. EPA type certification	CG9					
17	BW	Commercially Available Technology	CAT6	Interconnection technologies. Other barrier: Need to adopt standards	CG8					
18	TR	Commercially Unavailable Technology	CUT1	Develop advanced sensor technology	CG1					
19	BLANK	Commercially Unavailable Technology	CUT2	"Smart" soot blowers; pulse detonation at smaller scales; materials development	CG1					

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Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
20	CR, CMc	Commercially Unavailable Technology	CUT3	Work with coating companies to broaden the use of their~~apply utilize~~ coating products and technologies to solve CHP barriers ~~between applications~~; sharing research and development or patents	CG1					
21	JT	Commercially Unavailable Technology	CUT4	Economic scaled-down heat recovery equipment for small-scale operations	CG2					
22	CR	Commercially Unavailable Technology	CUT5	Provide gas treatment systems to fit smaller installations; refine CHP technologies that don't require gas treatment	CG2					
23	CMc	Commercially Unavailable Technology	CUT6	Material testing for Stirling engine piston solution; redesign of Stirling thermocouple/engine design	CG3					
24	TR	Commercially Unavailable Technology	CUT7	Advanced heat pump processes	CG4					
25	JT	Commercially Unavailable Technology	CUT8	Cost-effective low/moderate heat recovery	CG4					
26	JT	Commercially Unavailable Technology	CUT9	Direct conversion of heat to electric power	CG11					
27	BW	Commercially Unavailable Technology	CUT10	Thermal equivalent to photovoltaic cells heat recovery modules that generate electrical power directly from waste heat stream (liquid and gas)	CG11					
28	SK	Commercially Unavailable Technology	CUT11	Modular plug-and-play cogeneration/CHP that can be relocated/reused (positive salvage value)	CG5					
29	WC	Commercially Unavailable Technology	CUT12	Integration of renewable gas supply (anaerobic digester gas, landfill gas, agricultural/waste product gases, etc) with stationary CHP fuel cell systems which require higher-purity fuels than engines or turbines	CG6					
30	WC	Commercially Unavailable Technology	CUT13	Thermally well-integrated stationary CHP fuel cell systems with lithium-bromide or ammonia water absorption chillers	CG6					
31	WC	Commercially Unavailable Technology	CUT14	Computer simulation tools for determining the optimal combinations of CHP generators, combined cooling, heating, and electric power (CCHP) generators, thermal storage, cooling storage, and electrical storage	CG7					
32	SK	Commercially Unavailable Technology	CUT15	Waste heat expansion of pressurized gas and air	CG7	stored and shaped CHP power				

CHP Technology Roadmap Group: **CHP Production**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
33	SK	Commercially Unavailable Technology	CUT16	Recovering waste heat of compression (for use and/or storage)	CG7	stored and shaped CHP power				
34	BW	Commercially Unavailable Technology	CUT17	Standardized power conversion modules with input from electrical generation device, with output to facility power bus	CG8					
35	WC	Commercially Unavailable Technology	CUT18	Independent verification by an unbiased, third-party with no vested interests in a particular company of air pollution and greenhouse gas emissions measured in real time under cycling conditions	CG9					
36	WC	Commercially Unavailable Technology	CUT19	Independent data acquisition and analysis of real-time electricity and heat demand at industrial facilities, i.e., we need to quantify the baseline	CG10					
37	TR, MF	Commercially Unavailable Technology	CUT20	Researchers at the University of Utah (http://www.physics.utah.edu/~woolf/acoustics/bio.html) and MIT (http://web.mit.edu/mitei/research/spotlights/making-electricity-with-photovoltaics.html) are working on heat --> sound --> light --> electric power. These should allow for dirty gas to be converted to CHP without the cost impacts of scrubbing or burning dirty fuel in engines	CG10					
38	WC	Commercially Unavailable Technology	CUT21	More independent verification of emerging/early commercial CHP systems, especially fuel cells	CG10					
39	TR	R&D Programs: Existing R&D Program	ERD1	Sensor applications. Research ongoing at ~~ERRI [EPRI?]~~ EPRI	CUT1					
40	CMc	R&D Programs: Existing R&D Program	ERD2	Redesign materials for piston rings and thermocouple probes. Research ongoing at Stirling Biopower (http://www.stirlingbiopower.com/STIRLING/BASSE.swf)	CUT6					
41	TR	R&D Programs: Existing R&D Program	ERD3	Experimental work with heat pump technology through developing performance maps. Research ongoing at Electric Power Research Institute (EPRI) (http://www.epri.org/epriorg/EPRIorg_Home.php), Oak Ridge National Laboratory (http://ornl.gov/),	CUT7					
42	BW	R&D Programs: Existing R&D Program	ERD4	U.S. DOE/PPG Industries /Pacific Northwest National Laboratory study, see "Advanced Thermoelectric Materials for Efficient Waste Heat Recovery in Process Industries" (http://www1.eere.energy.gov/industry/imf/pdfs/14cps_16947_advanced_thermoelectric_materials.pdf)	CUT9	CUT10				
43	CR	R&D Programs: Existing R&D Program	ERD5	More efficient, compact, and long-lasting thermoelectric materials used in batteries. See Marlow Industries (http://www.marlow.com/resources/future-concepts/power-generators-page2.html)	~~energy storage~~ CUT9	CUT10				
44	WC	R&D Programs: Existing R&D Program	ERD6	Demonstration of anaerobic digester gas coupled with fuel cell systems. R&D should focus on reducing the very high cost of the gas processing and fuel cell integration.	CUT12					

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Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
45	TR	R&D Programs: New R&D Program (R&D Gap)	NRD1	Need for new materials for sensors	CUT1					
46	CR	R&D Programs: New R&D Program (R&D Gap)	NRD2	Materials testing for corrosive streams ~~(not sure if existing or gap)~~	CUT2	CUT3				
47	CMc	R&D Programs: New R&D Program (R&D Gap)	NRD3	Pre-package systems to limit engineering costs; standardize small units as normal production models, flexibility to phase-in additional units for future growth; material testing to drive-down production costs	CUT4	CUT5				
48	TR	R&D Programs: New R&D Program (R&D Gap)	NRD4	Low-cost heat pump systems with high coefficient of performance (contact Nyle Special Products LLC (http://www.nyle.com/))	CUT7	CUT8		See Note 1 below		
49	JT	R&D Programs: New R&D Program (R&D Gap)	NRD5	Demonstrate cost-effective low/moderate heat recovery (organic Rankine cycle, Kalina Cycle® ~~Cycle™~~, or other) in industrial environments	CAT 1					
50	BW	R&D Programs: New R&D Program (R&D Gap)	NRD6	Continue ~~Added~~ research to result in commercial materials & systems for direct conversion of thermal energy to electrical energy	CUT9	CUT10				
51	SK	R&D Programs: New R&D Program (R&D Gap)	NRD7	CHP asset redeployment strategies (enhanced salvage value for failed projects); designed to increase project financeability	CUT11					
52	JT	R&D Programs: New R&D Program (R&D Gap)	NRD8	Develop standards for modular/portable CHP technology to encourage secondary market/use of CHP equipment to reduce risk	CAT 2					
53	WC	R&D Programs: New R&D Program (R&D Gap)	NRD9	Commercialization modeling tools for ~~currently~~ current commercial CHP fuel cell generators to help industry analyze optimal installed capacities, operating and control strategies for CHP fuel cell generators at their facilities	CAT 3	CAT 4				
54	WC	R&D Programs: New R&D Program (R&D Gap)	NRD10	Development of design tools ultimately to be used by industry to select the optimal installed capacity of a CHP or combined cooling, heating, and electric power (CCHP) generator for a facility as well as optimal operating and control strategies	CUT13	CUT14	CUT30 (?)	CUT31 (?)	CUT32 (?)	CUT33 (?)
55	SK	R&D Programs: New R&D Program (R&D Gap)	NRD11	Reverse fuel switching (gas to power)	CUT15					
56	SK	R&D Programs: New R&D Program (R&D Gap)	NRD12	Industrial energy storage and shaping technologies	CUT16					

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No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
57	WC	R&D Programs: New R&D Program (R&D Gap)	NRD13	Develop phase 1 computer simulation tools for optimizing combined cooling, heating, and electric power (CCHP) generation and storage at industrial facilities. Tools can identify optimal installed capacities, control strategies, and deployment and installation approaches. Phase III models could be ultimately used by industry directly	CUT14					
58	TR	R&D Programs: New R&D Program (R&D Gap)	NRD14	Standards development	CAT 6					
59	SK	R&D Programs: New R&D Program (R&D Gap)	NRD15	What CHP technologies offer enhanced value for utilities in future power system (more intermittent renewable, electric vehicles, etc.)	CAT 4					
60	DS	R&D Programs: New R&D Program (R&D Gap)	NRD16	Develop type certification air quality emission profiles to U.S EPA data standards for biogas engines	CAT 5					
61	BW	R&D Programs: New R&D Program (R&D Gap)	NRD17	Create standardized power conversion modules for interconnecting site's generator power with site's power bus	CUT17					
62	WC	R&D Programs: New R&D Program (R&D Gap)	NRD18	Real-time data acquisition and data monitoring by an independent third party to analyze engineering, economic, and environmental performance of CHP and combined cooling, heating, and electric power (CCHP) distributed generators at industrial facilities. Emissions and solid waste should be monitored	CUT18	CUT21				
63	JT	R&D Programs: New R&D Program (R&D Gap)	NRD19	Quantify heat and electricity demand and temperature of demand at industrial facilities (in real time)	CUT19					
64	WC	R&D Programs: New R&D Program (R&D Gap)	NRD20	Independent data acquisition and analysis of heat demand, electricity demand, and the temperature of heat demand in real-time at one second time intervals in industrial facilities	CUT19	CUT21				
65	MF	R&D Programs: New R&D Program (R&D Gap)	NRD21	Nano technology is being explored for heat --> power from biogas. See work of Grant Norton, Chemical Engineer, Washington State University (http://www.mme.wsu.edu/~norton/)	CUT20					
66	TR	R&D Programs: New R&D Program (R&D Gap)	NRD22	Identify emerging technology options for industrial as a program area	CUT18	CUT19	CUT20	CUT21		
67	WC	R&D Programs: New R&D Program (R&D Gap)	NRD23	Demonstration of landfill gas and agricultural/waste product gases, and other biogas fuels, with stationary CHP fuel cell systems. Demonstration of sub-systems and sub-components to support this development	CUT7	CUT12				

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No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
68	WC	R&D Programs: New R&D Program (R&D Gap)	NRD24	Development of fuel cells, and fuel cell system components that are more resistant to impurities in biogas, landfill gas, and low-carbon or renewable fuels	CUT7	CUT12				

Note 1: ERDXX Demonstration of anaerobic digester gas coupled with fuel cell systems. R&D should focus on reducing the very high cost of the gas processing and fuel cell integration.
ERDXX Demonstration of anaerobic digester gas coupled with fuel cell systems. R&D should focus on reducing the very high cost of the gas processing and fuel cell integration.

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CHP Technology Roadmap Group: **CHP Delivery**

Codes: Higher Layer Item Linked

No.	Initial (particip ant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
1	ES	Capacity Gaps	CG1	Alternative power generator/CHP that stores power and heat to serve peak load	D32	D33				
2	MH	Capability	CG2	Technical knowledge to apply recovered heat from CHP.	D12					
3	GP	Capacity Gaps	CG3	Smart controls to adjust inputs (fuel) and outputs (heat & electricy) to meet resource (fuel) demand in an optimal	D90	D31				
4		Capability Gaps	CG4	How to use 140F and lower hot waste 1) between electricity 2) in processes.	D92	D38	D86			
~~5~~	~~GP~~	~~Capacity Gaps~~	~~CG5~~	~~Modular/portable CHP for multiple or changing "host"~~	~~D17~~	~~D14~~	~~D51~~			
6	CM	Capacity Gaps	CG6	Need improvements in the interface technologies between CHP generation and storage opportunities of fuel input	D87	D33	D31			
7	CM	Capacity Gaps	CG7	A central point of contact such as a NW-CHP working group that is available to consolidate technology, policy barriers and to develop solutions necessary to move CHP forward and						
8	ES	Capacity Gaps	CG8	Grid voltage, quality, k Var variability drives fuel cell system inverter to shut down	D88					
9	JW	Capacity Gaps	CG9	Heat storage capacity - What happens when facilities reach capacity to utilize heat/steam/other electricity	D4					
10	ES	Capacity Gaps	CG10	Fuel cell systems serving industral applications must operate 24/7 to maximize system efficency. Some applications use power 24/7 but heat less than 24/7. Gap is how to store heat until required by application	D4					
11	GP	Capability	CG11	Optimal use of low grade waste heat.	D92	D38	D86			
12	TA	Capability	CG12	Thermal measurements in plants.	D63	D41	D50			
13	GP	Capability Gaps	CG13	Bring together the disparate manufacturers and vendors (e.g. heat exchange industry) to apply expertise to the CHP	D86	D89	D90	D92		
14	JW	Capacity Gaps	CG14	Interconnection with grid to use thermal storage to balance excess renewables and intermittancy capacity.	D31	D33	D52	D15		
15	MH	Capability	CG15	How store electricity between BATT? Waste pump /	D90	D44	D50			
16	ES	Capacity Gaps	CG16	Hybrid CHP systems for industrial applications (e.g., solar & fuel cell or biomass & fuel cell) need one common inverter that's insensitive to grid var.	D88					
17	CM	Commercially Available Technology	CAT1	Interfaces currently exist with other technology, adapt to CHP Barrier: Technical Other: Cost	CG6					
18	ES	Commercially Available Technology	CAT2	Wide variety of commercial inverters are available. However, are they are insufficiently flexible to tolerate grid voltage variability and quality? Barrier: Technical	CG8	CG16				
19	ES	Commercially Available Technology	CAT3	Phase change materials exist for thermal storage. However, they need to be significantly tailored or developed for fuel cell applications.	**CG10**					
20	GP	Commercially Available Technology	CAT4	micro-technology and heat pump technology exists but needs to be refined, optimized and applied. Barrier: Technical	CG11	CG4	CG2			
21	MH	Commercially Available Technology	CAT5	Re-invigorate and make economically available pinch analysis on equivalence. Barrier: Technical	CG11	CG4	CG2			
22	MH	Commercially Available Technology	CAT6	Appropriately apply absorption chiller with CHP heat to provide low temperature (i.e. freezing is best to food processing?).	CG4					
23		Commercially Available Technology	CAT7	There is technology that needs to be applied. Some of these technology is in other industries and is found internationally (Europe).	CG12					
24	GP	Commercially Available Technology	CAT8	The individual technologies exist but these need to be a collaboration and good engineering to apply theses technologies well.	CG13					
25	GP	Commercially Available Technology	CAT9	Battery technology, or flywheel or other storage, has simply not yet been applied to CHP. Barrier: Technical	CG15					

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No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
26	ES	Commercially Available Technology	CAT10	Fuel cell power systems produce power and thermal energy but could be hybridized to reduce cost (e.g., solar and fuel cells when sun is available and fuel cells alone when no sun	CG1	CG14				
27	CM	Commercially Available	CAT11	Service currently exists for other technologies Barrier: None	CG7					
28	MH	Commercially Unavailable Technology	CUT1	Develop renewable (wind, solar?) technologies to makc CH4 from air (CO2 & H2O) to reverse combustion reaction so ebb can be stored, transported and available for conventional gas	CG1					
29	CM	Commercially Unavailable Technology	CUT2	Develop the technology for small & large scale applications	CG14					
30	GP	Commercially Unavailable Technology	CUT3	Smart grid technology is in infancy with most toechnologies still customized and not commercialized for industrial applications. Need software to tie smart grid technologies	CG3	CG4				
31	GP	Commercially Unavailable Technology	CUT4	CHP systems generally engineered for a specific application or industry. Not flexible or portable for quickly adapting to new or changing applications	CG5					
32	CM	Commercially Unavailable Technology	CUT5	Need to develop new, improved inverter technology to operate within a wide range of voltage, kVAR tolerances	CG8					
33	ES	Commercially Unavailable Technology	CUT6	Require new materials for low cost, highly efficient thermal energy storage (e.g. "beyond phase change" technology)	D4					
34	MH	Commercially Unavailable Technology	CUT7	Thermal driven (low temperature) heat pump to raise lower temperature water to usable temperature (see May-Ruben Technologies as a example)	CG4					
35	MH	Commercially Unavailable Technology	CUT8	Low temperature absorption (or other) chiller vapor lowest possible temperature (<140F) heat source.	CG4					
36	MF	Commercially Unavailable Technology	CUT9	Electrical energy storage for peak usage cost effective method to store 20 MWhr of electrical energy and cover 90% for later use.	CG15					
37	MF	Commercially Unavailable Technology	CUT10	Low grade heat utilization, 140-200F gas from boiler, or water from cooling tower to make electricity.	CG2	CG4	CG11			
38		Commercially Unavailable Technology	CUT11	Complete analysis to integrate CHP, process, and low heat temperature recovery.	CG11	CG12				
39	TA	R&D Programs:	ERD1	Thermal measurements / data collection system	CUT1 1					
40	GP	R&D Programs: Existing R&D Program	ERD2	Every major manufacturer of technology and DOE are working on new technologies to fill this gap. The challenge is to bring these technologies to the CHP industry. Where: Equipment manufacturers, National labs (e.g. PNNL), and universities (WSU-micro technology center)	CAT8					
41	GP	R&D Programs: Existing R&D	ERD3	Lots of battery technology R&D, but it is has not been directed at CHP applications (at least wide spread) Where: DOE, battery manufacturer, and auto manufacturer	CAT9					
42	CM	R&D Programs:	ERD4	Interface between CHP generation and resource storage	CAT1					
43	ES	R&D Programs: New R&D	NRD1	Engineering needed to match fuel cell thermal output to absorption chiller input require methods.	**CAT3**					
44	MH	R&D Programs: New R&D	NRD2	Improve absorption chillers to operate more efficiently on lower temperature driven heat and still achieve cooling, on better freezing.	CUT8					
45	MH	R&D Programs: New R&D	NRD3	Develop commercially viable thermal driven heat pump to lift low temperature (100-140^{o}F) heat to higher temperature (160-200 ^{o}F) so it can be utilized in process. (reference: May-	CUT7					

CHP Technology Roadmap Group: **CHP Delivery**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6
46	MH	R&D Programs: New R&D Program (R&D Gap)	NRD4	Find analysts) capable of perform full analysis of an operating plant for optimum effective energy use: integrate CHP, maximize other process heat recovery, utilize low temperature heat by new technologies. 1) Enables CHP by improving economics 2) avoid electricity use by direct thermal drive from	CG11					
47	MF	R&D Programs: New R&D	NRD5	Study if organic Rankiene is cost effective in a system: input - 140F H_2O or 170F boiler exhaust gas, output - 50F H_2O or cool exhaust gas, and heat pump process producing	CUT10					
48	ES	R&D Programs: New R&D	NRD6	Engineer fuel cell systems to run 24/7 (to maximize efficiency), but store electricity and heat as needed when on-site applications do not requiure electricity or heat or both	**CUT1**					
49	MH	R&D Programs: New R&D Program (R&D	NRD7	Develop technology to convert renewable power (wind, solar, etc.) to CH4, in other words reverse of fuel cell. CH4 can be stored, transported and used to generate renewable electricity on demand. Also more fuel! Renewable! Or just heat.	CUT10					
50	TA	R&D Programs: New R&D	NRD8	Modular/portable CHP ~~=>~~ microturbine fuel cell on ~~sheels~~ wheels	CUT4					
51	ES	R&D Programs: New R&D	NRD9	New inverter/ smart inverter needed specifically for MW-scale fuel cell systems. R&D underway for ~~PU~~ PV systems but not for fuel cell power plants. (Can a programmable inverter serve	CUT5					
52	GP	R&D Programs: New R&D Program (R&D Gap)	NRD10	Smart technology exists for this application but new interface and sofware needs to be developed. This could include smart technology for individual industrial equipment inside the plant linked to CHP system to give comprensive ability to manage load and supply to meet price signals.	CUT3					
53	ES	R&D Programs: New R&D	NRD11	Engineer existing phase change materials (e.g. molten salts, etc.) to match fuel cell thermal production at MW-scale level.	CAT3					
54	CM	R&D Programs: New R&D	NRD12	Flexible inverter technology to accommodate grid voltage variability and quality	CAT2	CG8				
55	WC	R&D Programs: New R&D Program (R&D	NRD13	Demonstration of hybridized fuel cell systems coupled with other technologies. The hybridized system provides more value than the individual technologies alone. Aims may include fuel consumption minimization and/or energy storage	CAT10					
56	WC	R&D Programs: New R&D Program (R&D Gap)	NRD14	Demonstration of fuel cell systems coupled with intermittent renewables to help mitigate the variability/intermittency of renewables. Demonstrate the technical viability and show the financial and technical value of reducing the variability of intermittent renewables (including wind, solar photovoltaic,	CAT10					
57	WC	R&D Programs: New R&D	NRD15	NRD15 Demonstrate absorption chillers coupled with CHP systems for providing chilling and/or freezing and power to industry	CAT6					
58	WC	R&D Programs: New R&D	NRD16	Demonstration of fuel cell systems coupled with intermittent renewables to mitigate the negative impacts of the renewables on the grid	CAT10					

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Northwest Energy Efficiency Technology Roadmap Portfolio
Combined Heat Power Workshop, Dec. 15, 2011
(with stakeholder revisions of Jan.-Feb, 2012)

CHP Technology Roadmap Group: **CHP Resources**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	Link 7	Link 8	Link 9	Link 10	Link 11
1	CMc	Capability Gaps	CG1	Need CHP system that handles dirty biogas or cheap biogas scrubbing - waste water treatment.	D93										
2	DS	Capability Gaps	CG2	Supply chain for competent CHP engineering and analysis. Right solution for specific application training gap.	D40	D59									
3	DS	Capability Gaps	CG3	Need better biomass waste drying and improved CHP systems that rotary drum or hot air.	D9										
4	TA	Capability Gaps	CG4	Biomass gasification.	D5										
5	EBM	Capability Gaps	CG5	Decrease the transportation costs to transport the fuel resources.	D5										
6	GP	Capability Gaps	CG6	Price estimates of natural gas in 20 years with certainty to enable planning.	D2	D21									
7	ES	Capability Gaps	CG7	Multiple waste fuels combined as feed stocks / fuels for CHP generation (e.g.. Biomass and biogas, or biogas and	D87										
8	ES	Capability Gaps	CG8	~~Render~~ Make CHP systems ~~(MW-scale). Fuels~~ (mW-scale) fuel flexible to enable fuel switching based on fuel price.	D87										
9	WC	Capability Gaps	CG9	Absorption chillers cold enough for freezing and higher efficiency.	D93	D8	D30								
10	CR	Capability Gaps	CG10	No directory or database of engineering / construction firms with expertise in CHP & Its applications in various industries. Interested facilities don't know who to go to.	D18										
11	WC	Capability Gaps	CG11	Higher reliability electricity and heat provision to the industrial site by running the CHP generator continuously and able to operate even with a grid disconnect / grid outage.	D3	D19	D26	D38	D41	D48	D49	D50	D57	D68	
12	~~MH~~	~~Capability Gaps~~	~~CG12~~	~~Assume natural gas delivery transportation exists economically to support CHP, especially to support peak use. May take creative concept in contracts (Sufficient P/L capacity reduces need for storage vice versa).~~	~~D2~~	~~D21~~	(MH to Submit as policy								
13	WC	Capability Gaps	CG13	Ability to deploy rapidly, turn down, and turn up CHP generator to capture value / provide value to the electric grids balancing market and other services.	D15	D93	D17	D30	D45	D90	D88	D83	D61	D52	D54
14	DS	Commercially Available Technology	CAT1	CHP Barrier: Other - Engineering training	CG2	CG10									
15	ES	Commercially Available Technology	CAT2	Biomass gasifier are commercially available; require engineering to make more compatible with CHP generations (e.g.. Fuel cell systems).	CG4										
16	GP	Commercially Available Technology	CAT3	Multiple transportation strategies exist, but they need to be optimized for the particular application or location.	CG5										
17	ES	Commercially Available Technology	CAT4	MW-scale fuel cell power systems are fuel flexible but can be made significantly more affordable through fuel type. Barrier: Technical - Power plant optimization	CG7	CG8									
18	WC	Commercially Available Technology	CAT5	Some CHP is available that can rapidly load cycle but at low electrical efficiency and increased emissions. These generators may include internal combustion engines and	CG10										
19	WC	Commercially Available Technology	CAT6	CHP systems specifically engineered for operation under fast ramping conditions	CG13										
20	WC	Commercially Available Technology	CAT7	Systems composed of combinations of CHP generators and storage specifically engineered to supply critical power under loss of grid conditions	CG11										
21	WC	Commercially Unavailable Technology	CUT1	Biogas clean-up technologies for meeting the higher purity levels required by fuel cells.	CG1										
22	CMc	Commercially Unavailable Technology	CUT2	Biological gas treatment system self regenerating carbon media.	CG1										
23	TR	Commercially Unavailable Technology	CUT3	Develop training program for system suppliers of CHP.	CG2										
24	MF	Commercially Unavailable Technology	CUT4	Technology exists in Europe. New technology is coming off research at WSU that is a combination of unit processes that exist (UASB) and acid and biological controls.	CG (?)		Moved to Production?								
25	DS	Commercially Unavailable Technology	CUT5	Micro wave drying of wet biomass and higher temperature gasifiers.	CG3										

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CHP Technology Roadmap Group: **CHP Resources**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	Link 7	Link 8	Link 9	Link 10	Link 11
26	BW	Commercially Unavailable Technology	CUT6	Industrialization of non-conductor / convection energy materials for drying - IR-RF -MW (infrared - radio frequency - micro wave).	CG3										
27	WC	Commercially Unavailable Technology	CUT7	Commercial biomass gasification and purification at high energy purity levels for delivery to electrochemical CHP systems.	CG3		Moved to Production?								
28	MF	Commercially Unavailable Technology	CUT8	Pre-drying pre-treatment for slow and fast pyrolysis, primarily wood materials.	CG3										
29	WC	Commercially Unavailable Technology	CUT9	High efficiency, low cost absorption chillers for chilled water or freezing commercial chillers are typically single effect with a coefficient of performance (COP) <= 0.7.	CG9										
30	JT	Commercially Unavailable Technology	CUT10	Cost effective, efficient absorptions chilling (or other process) to convert heat to freezing.	CG9										
31	WC	Commercially Unavailable Technology	CUT11	Optimally thermally integrating absorption chillers with the heat supply from distributed CHP generators.	CG9										
32	WC	Commercially Unavailable Technology	CUT12	Inexpensive absorption chillers with a coefficient of performance >= 0.7.	CG9										
33	GP	Commercially Unavailable Technology	CUT13	Accurate prediction of natural gas prices 10-20 years from now.	CG6	CG11									
34	GP	Commercially Unavailable Technology	CUT14	CHP (such as fuel cell) that can automatically and transparently switch.	CG7	CG8									
35	WC	Commercially Unavailable Technology	CUT15	Demonstration electrical efficiency and low emissions even under rapid load cycling conditions. Possible future generators may include advanced fuel cell systems.	CG10										
36	WC	Commercially Unavailable Technology	CUT16	Diesel engines typically are not run continuously but rather only for back up due to limited supply of liquid fuel and high local air pollution emissions and legal restrictions on these.	CG11										
37	WC	Commercially Unavailable Technology	CUT17	CHP systems specifically engineered for operation under fast ramping conditons	CG13										
38	WC	Commercially Unavailable Technology	CUT18	Systems composed of combinations of CHP generators and storage specifically engineered to supply critical power under loss of grid conditions	CG11										
39	CM	R&D Programs: Existing R&D Program	ERD1	Self regenerating carbon media material	CUT1	CUT2									
40	MF	R&D Programs: Existing R&D Program	ERD2	Support and expand current programs to train graduates and post doctors for renewable industry with emphasis on new technology and ability to communicate complex ideas with the public	CUT3										
41	WC	R&D Programs: Existing R&D Program	ERD3	DOE laboratory directed research (LDRD) to thermal dynamically model solid oxide fuel cells coupled with single effect lithium bromide chillers. More work needed to model other types of fuel cells and chillers. DOE LORD at Sandia labs (now ended)	CUT9	CUT10	CUT11	CUT12	**CUT (?)**						
42	GP	R&D Programs: Existing R&D Program	ERD4	Transportation optimization is an R&D program across a number of sectors but not specifically addressing the issue. Where: DOE / OTT / universities	CAT3										
43	GP	R&D Programs: Existing R&D Program	ERD5	Most all utilities and energy companies run moduls to predict future energy prices. Are they complete or comprehensive enough? Where: Independent R&D (Cambridge Energy) utilities	CUT12	CUT13	**CUT (?)**								

CHP Technology Roadmap Group: **CHP Resources**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	Link 7	Link 8	Link 9	Link 10	Link 11
44	WC	R&D Programs: New R&D Program (R&D Gap)	NRD1	Development of a user friendly tool for industrial facilities to conduct a pitch point analysis to optimal thermal integration of heat streams from CHP with different quantities and temperatures of heat demanded at facility.	CAT1										
45	TR	R&D Programs: New R&D Program (R&D Gap)	NRD2	Organize workshops with known suppliers to establish a network and test for CHP competency.	CAT1										
46	CR	R&D Programs: New R&D Program (R&D Gap)	NRD3	Assemble directory of companies, and people with expertise in energy analysis and CHP construction. Distribute directory (to WSU EP esp.)	**CAT (?)**										
47	WC	R&D Programs: New R&D Program (R&D Gap)	NRD4	Independent verification of engine and turbine CHIP systems in the field that are run to address the balancing market (rapid load cycling conditions), Electrical efficiency, overall CHP efficiency, and emission should be measured in real time. The emission increase under rapid cycling.	CAT5										
48	WC	R&D Programs: New R&D Program (R&D Gap)	NRD5	Identify the specific needs of critical infrastructure, for example, facilities important for national security or for economic security such as data centers and custom design advanced CHP. CHP generators to meet these needs (demand curves, reliability requirement etc.).	CUT18	CAT5									
49	CMc	R&D Programs: New R&D Program (R&D Gap)	NRD6	Develop new gas treatment technologies	CUT1	CUT2									
50	MF	R&D Programs: New R&D Program (R&D Gap)	NRD7	Pre commercial pilot scale funding needed. Contact WSU (Craig Frear).	CUT4	**CG (?)**									
51	DS	R&D Programs: New R&D Program (R&D Gap)	NRD8	Commercialize high temperature brick kiln wood gasifier - Need performance data R&D - Octa Flame model 001 under construction - Springdale Lumber	CUT5										
52	DS	R&D Programs: New R&D Program (R&D Gap)	NRD9	Commercialize micro wave wet biomass drying systems - contact Rotawave Ltd. out of U.K.	CUT5										
53	MF	R&D Programs: New R&D Program (R&D Gap)	NRD10	Thermochemical pyrolysis program optimized moisture for fuel energy, biochar. Manuel Garcia Perez, WSU.	CUT8										
54	WC	R&D Programs: New R&D Program (R&D Gap)	NRD11	Chemical engineering process plant design studies modeling the most advanced absorption chillers (ammonia-water etc.) with highly advanced stationary CHP fuel cell systems.	CUT9	CUT10	CUT11	CUT12	**CUT (?)**						
55	WC	R&D Programs: New R&D Program (R&D Gap)	NRD12	Demonstration and independent testing and performance verification of any of these fuelcells solid oxide, molten carbonate, phosphoric acid, and proton exchange membrane - with any of these absorption chillers - double or triple effect lithium bromide chiller, ammonia water chiller.	CUT9	CUT10	CUT11	CUT12	**CUT (?)**						
56	WC	R&D Programs: New R&D Program (R&D Gap)	NRD13	Detailed computer modeling studies of optimal thermal integration of multiple fuel cell / CHP generator waste heat streams with multiple heat sink systems in the absorption chiller and at the industrial facility.	CUT9	CUT10	CUT11	CUT12	**CUT (?)**						
57	WC	R&D Programs: New R&D Program (R&D Gap)	NRD14	Demonstration of high efficiency, very tight thermal integration of fuel cell waste heat with multiple thermal sink streams in absorption chillers. This effort focuses on optimal thermal integration through pinch point analysis to drive up heat recovery and overall efficiency.	CUT9	CUT10	CUT11	CUT12	**CUT (?)**						
58	WC	R&D Programs: New R&D Program (R&D Gap)	NRD15	Verification and testing of specific independent CHP FCS that claim an ability to rapidly load cycle at high electrical efficiencies (>50%). Possible CHP FCSs may include the ceramic fuel cells limited solid oxide fuel cell system (SOFC)	CUT15										

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CHP Technology Roadmap Group: **CHP Resources**

Codes: Higher Layer Item Linked

No.	Initial (participant)	Roadmap Layer	Item Code	Item Description	Link 1	Link 2	Link 3	Link 4	Link 5	Link 6	Link 7	Link 8	Link 9	Link 10	Link 11
59	WC	R&D Programs: New R&D Program (R&D Gap)	NRD16	Independent verification of poor-start up reliability of distributed diesel generators for back up power and limited life times and efficiencies under conditions of continuous use.	CUT6										
60	ES	R&D Programs: New R&D Program (R&D Gap)	NRD17	Work needed to engineer 1) gasifier output temperature and pressure matched to fuel cell input temperature and pressure 2) gasifier output product quality matched to fuel cell input fuel quality (fuel value, contaminations)	CAT2										
61	ES	R&D Programs: New R&D Program (R&D Gap)	NRD18	Variety of waste fuels exist. R&D needed to learn how to blend them for fuel cell system use and to optimize fuel cell operation based on fuel value.	D45	D87									
62	ES	R&D Programs: New R&D Program (R&D Gap)	NRD19	This effort's scope is to determine how to optimize MW-scale fuel cell power plant operation (e.g. controls, operating temperatures, fuel clean-up if required).	CAT4	D87									
63	GP	R&D Programs: New R&D Program (R&D Gap)	NRD20	Highly flexible and module CHP that have capability to use multiple fuel with minimal "engineering" or even automatically with "price signals."	CUT14										
64	WC	R&D Programs: New R&D Program (R&D Gap)	NRD21	Independently measure the emission and efficiency of diesel generators for back up power, CHP, and under fast ramping conditions. This data can provide a benchmark of the current state-of technology, against which other technical solutions could be evaluated.	CUT16	CAT									
65	WC	R&D Programs: New R&D Program (R&D Gap)	NRD22	Computer simulation of fast ramping CHP systems in the context of the surrounding electricity market. Balancing markets more highly value generators with fast ramping capabilities. Simulation could focus on fast-ramping CHP systems exposed to these higher balancing market prices and to demand-response incentives from surrounding utilities. An aim of this research is to convey the additional financial value of fast-ramping CHP	CUT17	CAT6									
66	WC	R&D Programs: New R&D Program (R&D Gap)	NRD23	Demonstration and independent testing of CHP systems under fast ramping conditions. CHP systems may include fuel cells, engines, microturbines, and other technologies. Emissions and efficiency should be measured by an independent third party in real-time from these systems under ramping conditions. Measured values could inform computer simulation efforts done in parallel	CUT16	CAT6									
67	WC	R&D Programs: New R&D Program (R&D Gap)	NRD24	Computer simulation of CHP systems for back-up power in the context of the surrounding market. Simulation could focus on CHP systems exposed to higher prices for back-up power. An aim of this research is to convey the additional financial value of back up CHP	CUT18	CAT7									
68	WC	R&D Programs: New R&D Program (R&D Gap)	NRD25	Demonstration and independent testing of critical power CHP systems. Emissions and efficiency should be measured by an independent third party in real-time from these systems under ramping conditions. Measured values could inform computer simulation efforts done in parallel	CAT7										

Appendix A8:
Drivers & Capability Gaps Workshop (Aug. 8, 2012)

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DRAFT Agenda

National Energy Efficiency Technology Roadmap Workshop
—Drivers and Capability Gaps—
August 8, 2012

Location: BPA HQ, Room 122 (905 NE 11th Avenue, Portland, OR 97232)

Purpose of Workshop:

- Review and Confirm/Revise drivers and capability gaps identified for all commercial and residential roadmaps across the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio*.

Wednesday, August 8, 2012

8:00 am — Coffee

8:15 am — Welcome, Review, Description of Goals and Process for Workshop
Terry Oliver, *Bonneville Power Administration*
Joshua Binus, *Bonneville Power Administration*

9:00 am to 12:15 pm — Divide into Subgroups per Product/Service Area;
Review and Confirm/Revise Drivers and Capability Gaps

Each Subgroup will:

9:00	Address 1st Batch of Roadmaps (Drivers, Capability Gaps, Orphans)
10:30	**Break**
10:45	Address 2nd Batch of Roadmaps (Drivers, Capability Gaps, Orphans)

12:15 pm — Lunch

1:00 am — Sub-Group Report-Out/Discussion

3:00 am — Presentation/Discussion on Proposed Revisions to *Roadmap Portfolio* Organization Structure (for the March 2013 Draft)

3:45 pm — Break

4:00 pm — Prioritization Overview and Q&A

4:30 pm — Closeout Meeting and Adjourn

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National Energy Efficiency Technology Roadmap Workshop

Drivers & Capability Gaps for
Residential & Commercial Roadmaps
August 8, 2012

What to expect, today?

- Today's work is part of a national effort to revise a portfolio of energy efficiency technology roadmaps designed to:
    1. support the development of a shared, strategic research agenda;
    2. provide transparency regarding ongoing R&D efforts;
    3. limit redundant investment; and
    4. facilitate coordination and collaboration.
- Primary Focus: Revise Drivers/Capability Gaps for Res. & Comm. Roadmaps
    - Output from today's workshop will provide jumping-off point for September Roadmapping Summit
- Secondary Focus: Discuss proposed revisions to portfolio organizational structure
    - Revisions to be implemented for March 2013 draft of *Roadmap Portfolio*

- These roadmaps are meant to be living documents, updated and revised as needed
- There are many ways to carry out this kind of process; today's effort reflects only one approach
- Thanks to NEEA for providing us with coffee and food
- Bathrooms are located just past the elevators, to the left of the guard station. Please wear your tag and don't wander beyond the halls beyond the bathrooms.

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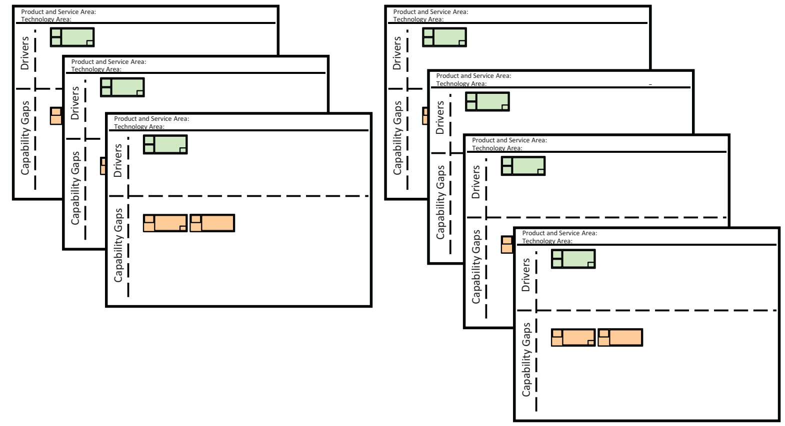
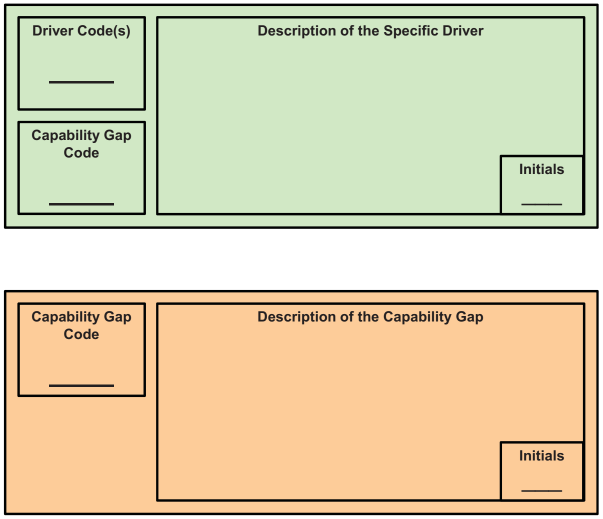
Task 1: Organize Roadmaps into 2 Batches



Task 2: Review & Revise Batch 1

- Task 2A: Review & revise capability gaps
- Task 2B: Review handout of existing high-level drivers
    - If possible, identify street-level drivers associated with each capability gap (make sure to identify linkages)
    - If not possible, link capability gaps to specific high-level driver(s)
- Task 2C: Review handout of orphans; integrate any technology-specific orphans into appropriate roadmaps, making sure to link them to driver(s)



Task 3: Review & Revise Batch 2

- Repeat steps used for task 2
- Time permitting, provide supporting text justifying importance/relevance of non-technological orphans
  - While these latter orphans don't belong in the actual roadmaps, we want to make sure to provide some text on their importance in the adjoining text for each roadmap.

Task 4: Subgroup Reporting

- Each subgroup will report efforts to the larger group
- All workshop participants will have an opportunity to ask questions and provide comments on the output of other subgroups
- Verbatim minutes will capture the discussion for use in post-workshop processing

Task 5: Presentation & Discussion on Proposed Revision to *Roadmap Portfolio* Organizational Structure

- Existing organizational structure is an artifact of first efforts out of the gate
  - It has been useful, to date, but we think there is a better way to keep things organized, moving forward
- Review handouts and discuss
- Discussion will be captured through verbatim minutes
- **Additional comments/suggestions are welcome through Aug. 31st (send to jdbinus@bpa.gov)**

What's next?

- **Sept. 24 – 27 National Energy Efficiency Technology Roadmapping Summit**
  - @ DoubleTree Hotel in Portland, OR
  - Summit participants will review/revise technology features and R&D Projects
  - A portion of each summit workshop (~1 hr) will be dedicated to the prioritization of emerging technologies
- Prioritization of R&D projects will be facilitated via webinar and online survey (post-Summit)
- Next official *Roadmap Portfolio* draft: March 2013
- FY13/FY14: Begin piloting *Roadmap Portfolio* migration to the web (with password-protected wiki capability to enable real-time editing)

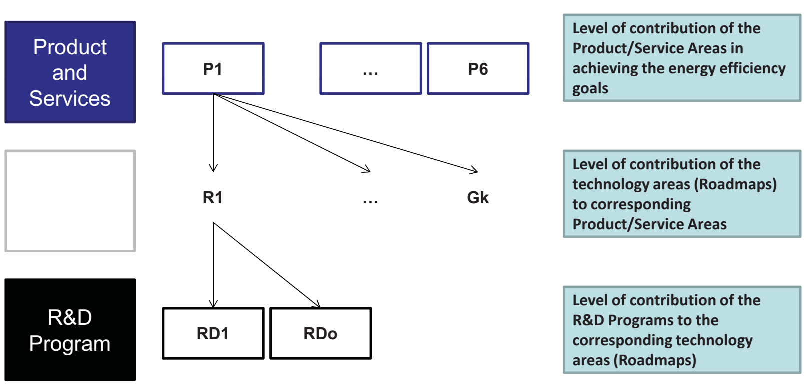
National Energy Efficiency Technology Summit Schedule Portland, Oregon | Sep. 24-27, 2012

DRAFT July 26, 2012

7:30 · 8:00 · 8:30 · 9:00 · 9:30 · 10:00 · 10:30 · 11:00 · 11:30 · 12:00 · 12:30 · 1:00 · 1:30 · 2:00 · 2:30 · 3:00 · 3:30 · 4:00 · 4:30 · 5:00

Monday, Sep. 24			Tuesday, Sep. 25		Wednesday, Sep. 26			Thursday, Sep. 27	
Coffee			*Coffee*		*Coffee*			*Coffee*	
Welcome & Opening Remarks			Welcome		Welcome			Welcome & Closing Plenary (available via webinar / live video feed)	
Panel Presentations for the Building Design / Envelope product and service area will commence at 1:00 p.m.	PANEL PRESENTATIONS Lighting	ROADMAP WORKSHOP *[to commence with brief state-of-the-field presentations]* Sensors / Meters	PANEL PRESENTATIONS Building Design / Envelope	ROADMAP WORKSHOP Lighting	ROADMAP WORKSHOP Building Design / Envelope	PANEL PRESENTATIONS HVAC	PANEL PRESENTATIONS Electronics	ROADMAP WORKSHOP HVAC	ROADMAP WORKSHOP Electronics
Keynote (available via webinar / live video feed) *Buffet Lunch*			*Buffet Lunch*		*Buffet Lunch*			*Buffet Lunch*	
PANEL PRESENTATIONS Building Design / Envelope	PANEL PRESENTATIONS Lighting	ROADMAP WORKSHOP Sensors / Meters	PANEL PRESENTATIONS Building Design / Envelope	ROADMAP WORKSHOP Lighting	ROADMAP WORKSHOP Building Design / Envelope	PANEL PRESENTATIONS HVAC	PANEL PRESENTATIONS Electronics	ROADMAP WORKSHOP HVAC	ROADMAP WORKSHOP Electronics

Proposed prioritization methodology



Highest possible score for R&D program would be 1000 (10x10x10)

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National Energy Efficiency Technology Roadmap Workshop
Drivers & Capability Gaps for Residential & Commercial Roadmaps

August 8, 2012

Verbatim minutes of Task 4 & Task 5 Discussions

Revised Oct. 10, 2012

Attendees & Workgroup Participation

Building Design / Envelope

1. Ayoub, Amanda (PECI)
2. Baechler, Michael (PNNL)
3. Casentini, Lauren (Resource Solutions Group)
4. Currier, Todd (WSU)
5. Gleeson, Jeff (PG&E)
6. Husted, Rem (PSE)
7. Johnson, Mark (BPA)
8. Little, Michael (SCL)
9. Manclark, Bruce (Fluid Marketing Strategies)
10. Pengilly, Pete (Idaho Power)
11. Roberts, Dave (NREL)
12. Zeiger, Jack (WSU)
13. Zoeller, Brian (BPA)

Electronics

14. Hardy, Gregg (Ecova)
15. Harris, Jeff (NEEA)
16. Livingston, Jonathan (LEI)
17. Panzer, Aaron (PG&E)
18. Reddoch, Thomas (EPRI)

Heating, Ventilation, & Air Conditioning

19. Baylon, Dave (Ecotope)
20. Fedie, Ryan (BPA)
21. Petrill, Ellen (EPRI)
22. Smith, Mary (SnoPUD)
23. Stephens, Charlie (NEEA)
24. Volkman, Jim (Strategic Energy Group)

Lighting

25. Hewitt, Dave (NBI)
26. Nock, Levin (BPA)
27. Penney, Rob (WSU)
28. Rehley, Mark (NEEA)
29. Sklar, Paul (ETO)
30. Williamson, Jennifer (BPA)
31. Kelleher, Gregg (EWEB)

Sensors, Meters, & Energy Management Systems

32. Ander, Gregg (SCE)
33. Barra, Joe (PGE)
34. Callahan, Jack (BPA)
35. Effinger, Joan (PECI)
36. Erben, Erin (EWEB)
37. Higgins, Cathy (NBI)
38. Marques, Jorge (BC Hydro)
39. Mathew, Paul (LBNL)
40. Livingood, William (NREL)

Facilitators & Support Staff

1. Joshua D. Binus (BPA)
2. Tugrul Daim (PSU)
3. James V. Hillegas (BPA)
4. Ibrahim Iskin (PSU)
5. Joseph Thomas (BPA)

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Task 4: Subgroup Reporting

Building Design / Envelope

Gleeson: I have a proposal: Instead of grabbing the individual roadmap posters and reading the cards on them, we want to focus on the drivers we came up with because that's where we concentrated our efforts.

The first thing on our list is that in rating components of retrofits we need an apples-to-apples comparison between the various rating systems, such as Leadership in Energy & Environmental Design (LEED) and many others. Having this diversity without such a direct comparison between these systems is not helpful. Our discussion involved adding this aspect coming from both a standards perspective and, for new technology development, a labeling perspective.

The next driver we came up with is along the same lines. We need to be able to differentiate the various value propositions of labeling for different market segments. Developers, vendors, realtors, tenants, and others will understand the value propositions differently, and we need a system to be applicable to these diverse groups.

Another driver is for good daylighting technologies in high-performance buildings. Next there is a driver that pertains to manufactured homes, and Mark, you had a lot of input on this, do you want to explain it?

Johnson: Within the manufactured homes industry, the manufacturers only buy from a limited number of distributors, which means that if this short list of distributors doesn't carry a particular product, the product doesn't get purchased.

Binus: How does this driver pertaining to product supply at distributors lend itself to a capability gap that can be treated with technology?

Gleeson: That's a good question and we can go deeper into that later if time allows.

Our next driver is about codes. We sort of touch on market acceptance of labeling systems. In the existing roadmap portfolio within this product and service area, there is a capability gap that relates to requiring market acceptance of labeling systems. We had a question about the feasibility of trying to require this of the market.

Another of our drivers is that we've got to be able to build mobile homes in such a way as to be able to get rid of ducts.

Another new driver is the need to reduce callbacks to fix contractor oversights and reduce the amount of warranty replacements. Contractors need to reduce the number of callbacks, so we need better product standards.

Currier: Commercial buildings typically have wall systems that provide inadequate insulation and don't have a very high R-values. We would like to see some better R-values and more attention to sealing for airtightness.

Gleeson: Another new driver that definitely includes a technology component is the need to increase the occupational health, safety, and comfort, which involves measuring the interior environments of buildings.

Related to this, there's a lack of uniform codes and code enforcement which indicates a need to enhance quality assurance for building shell retrofits.

We next come to the cost effectiveness of programs for utilities. We haven't yet connected this driver to the capability gaps. This brings us to the next driver, which is the cost allocations of these various programs. The cost allocations look very poor, but utilities didn't' [did not capture full statement here].

This brings us to the need for cost-effective assessment of structures, including a better and more scalable way to determine how and when a building owner should do a retrofit project.

Another driver is that fire sprinkler codes proliferate. With all these sprinklers going in, there is an increased need to seal around penetrations. The solution to this might not necessarily be a technology, but it could involve bringing sensors into the ventilation space.

Another question we had as a group was: Why are we going to net zero energy? Why not get to 5 or 10 percent?

That's the last one that we have.

Binus: Great, thanks. For those of you who also have expertise in this product and service area, is there anything else that you think needs added to the drivers mentioned, or the capability gaps, or do you have questions?

Baylon: Your comment that energy codes are not uniform mystified me. They are pretty uniform within a given state.

Gleeson: We were talking about inconsistency in installation; it's also an enforcement issue.

Erben: I'm not sure how prevalent it is, but not all states have uniform codes.

Baylon: They do in the Pacific Northwest.

Hewitt: Regarding these drivers, we at the New Buildings Institute work with a lot of states pushing net zero energy, so it seems that state policy could very well be a driver in this area.

Gleeson: That's a good point, and we had net zero energy items in our list. A lot if it gets to determining the right size for a given application—scalability.

Zeiger: Another comment is that our group had fifteen total roadmaps. At the beginning we had to figure out how to divide all of these into two groups. We did not come to complete consensus on how to divide our roadmaps into groups to work on, but we did agree to divide them by the categories of New Construction and Retrofit.

Livingood: I'm not sure if this is a driver or a capability gap. We all know the benefits of open integration, but here are many impediments to this. In the commercial space, there are these antiquated procurement processes that get in the way. When whole building integration is incentivized to overcome the antiquated processes, only then will it become a reality. We're seeing some of that, but that needs to be further developed in the design-build world and it needs to expand to the design-build-bid world.

Currier: Dave Baylon's comment is important.

Hewitt: Another thing we're looking at is driving for deep levels of energy efficiency in retrofit and innovation. This could be a separate driver. We see in New York City, for example, that they're already raising the bar. The pressure is on the built stock and how to get high levels of energy efficiency. This will take some leaps in technology, such as wireless systems, where we can make significant upgrades and improvements in retrofitting buildings with much less cost and effort than was possible previously.

Husted: Getting away from the utility model in deep retrofits is something we talked about. Such as finiancing and other mechanisms that are going to take over the retrofit process.

Marques: Was your main focus on attached homes, or also on residential high rise homes as well?

Gleeson: We did not talk about multifamily homes.

Binus: Within the Roadmap Portfolio as it now exists, it is a mashup of commercial and residential within a single roadmap, as well as single-family and multi-family residential. In our first iteration we were residential-heavy. In this workshop today we tried to bring in some more commercial experts to the table to expand things. And last year we brought in industrial experts to help us create roadmaps on industrial food processing and combined heat and power. We know that there are gaps in the Roadmap Portfolio that need to be treated, and that there is a lot of work left to be done.

Currier: That said, if there are some specific drivers unique to these other areas, we should get them on the list as well.

Marques: One big driver in multifamily and commercial buildings is the window-to-wall ratio. In these kinds of buildings, envelope assembly performance is nowhere near what they are in models. When these ideas are put into

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place, we find that the builders and designers don't consider all of the thermal breaks. We're finding that high-rise condominium apartments are actually using more energy than single-family homes, once you consider the elevators, makeup air units, and other systems.

Baylon: In Seattle we're making similar observations, but not because of glazing but because of ventilation systems.

Marques: Air is escaping through makeup air units.

Higgins: Did you address integrated photovoltaics in facades? I think we'll see more of that over the coming twenty years.

Gleeson: Yes we did.

Sensors, Meters, & Energy Management Systems (Sensors)

Erben: The first driver we came up with involves market-driven communications and interface standards. Standards are a big issue for us. We found that for our six roadmaps, we had capability gaps that crossed roadmaps, so we talked about where they overlapped. In general, one gap that jumped out was that we need to use business analytics better. We're not using it terribly effectively. We don't have the algorithms or feedback loops in place to use all of the data that we're able to collect. Also, we need to use data better in real time so that maybe the data doesn't have to be stored.

Livingood: A gap that was pretty common throughout our areas was tools such as [name?] and [name?] that claimed to solve the interoperability problems, but when these tools have been fully vetted we've found that these claims are not actually true.

Erben: Another was cost. Producing low-cost widgets that could be integrated for mass production and deployment. Another theme was consumer interest: When technologies are available but have some issues in being mass-produced or put to use, this is often a technical gap, but maybe we need to check-in with consumers to ensure that we're building the right technologies.

Measurement and verification was also a pretty big theme for us. Everyone knows that standard protocols are pretty vague.

Livingood: We also discussed performance standards, and one of these was low-cost techniques. Costs of energy efficiency investments as well as demand investments. As we move more and more toward performance-based procurement where we procure and expect certain energy efficiency savings, the expectation will be that measurement and verification tools and techniques improve significantly as well.

Erben: We discussed a need for customization and standardization at the same time. In the future, technology may get to the point where the systems can program themselves rather than require that customers do the programming.

Lastly, we need business drivers to make sure that we link what manufacturers produce with what customers want, and link all of this with what we think customers should be wanting.

Is there anything else to add?

Currier: There are a couple of others drivers that seemed to be quite strong as well in our group. One was escalating energy prices. Related to that was a pretty strong driver linked to energy management systems was the changing utility rate structures involving time of use. Just the pure complexity of rate structures creates gaps between the information systems and analytics simply being able to deal with all of this information in a meaningful and timely way. In the past you couldn't do much with all of this information. Now there are increasingly more complex information technologies, and when these become more prevalent, suddenly there comes a time where the information systems can use this data and make it easy for end users to make sense of and use. A big theme that we see is that people are overwhelmed with data. They're also overwhelmed with questions about how to take complex data and systems and manage the system automatically.

Higgins: The New Buildings Institute focuses on some policy drivers. If you want to have some kind of standardization in driving energy control and management, then you need to have standard disclosure and rating mechanism to drive the development of technology to deliver this kind of information.

Baylon: I would have thought that a discussion of energy management systems would have involved the question of *what* was being managed, not just the *way* it is managed. Things like having HVAC systems or whatever. It isn't necessarily true that just because you have the ability to control various parts of the building doesn't mean that you should do this, or that if you do control such things that this automatically makes things better. Were these kinds of considerations included in your discussion?

Erben: Those are great points. We didn't address these points specifically, but we did address it through the lens of the customer and finding out what they want. We did talk about the need for additional market intelligence to figure out what customers want and need.

Baylon: It's almost always the case that the customer doesn't have a clue about the quality of their energy management system.

Marques: Are there drivers out there for this? Is something driving the need for improved whole-building energy management systems that customers can use more easily and intuitively?

Erben: Good points. I think the question becomes, just because we can do something, should we?

Baylon: Right. In a lot of cases we should also ask if we can just turn of the systems entirely.

Effinger: If we look twenty years from now, it's entirely likely that these systems become living systems where they will know themselves and manage the building environment outside of user input.

Marques: Like your car. Cars these days make all kinds of decisions for you as you're driving, and the driver is unaware.

Baylon: And is that a good thing or a bad thing?

Higgins: On the question of "good" and "bad," there are differences in different sectors.

Baylon: There is research out there that shows surprisingly good energy efficiency returns if the systems know simply when to turn itself off or on—not going into a low-energy-use mode, but shutting off entirely.

Hardy: Like the Prius, which provides just enough information for the user to monitor fuel usage and save fuel, but not too much information and by way of an uncomplicated user interface.

Petrill: This sounds like two distinct drivers, one about trying to understand behavior patterns better, and another about how to design technologies that benefit from this understanding to deliver energy efficiency.

Callahan: I have a question for Joshua Binus about this. It's good for us to question the notion of what systems are being controlled. Each of these roadmaps focuses on different pieces of this idea. They're not always *energy management* systems, though; sometimes they are *control* systems. We focused on energy management systems, but they're often overlayed with control systems. A question is, how do these two kinds of systems mesh-up? We don't have a box for that. Joan was looking at this and it wasn't making sense.

Effinger: Yes, I would organize the roadmaps in this product and service area differently.

Binus: Great points, and that's our next agenda item so you might want to hold those thoughts until then. To summarize, the structure that we've used up to this point is an artifact of the earliest steps in this multi-year roadmapping process. We've been using this organizational structure to date, but now we think there is a better way, and later this afternoon we'll have time set aside to discuss this in more depth.

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Effinger: Ok, I'll save most of my thoughts, but some of the categories we came up with were metering, system level, and building level, and then others that are data management and usability.

Binus: We'll get everyone's input on the Roadmap Portfolio reorganization and use this input to create a revised strawman document for the September Technology Summit. Summit attendees will then give us further suggestions and we'll fold all of this in to a thorough overhaul of the Roadmap Portfolio in time for the March 2013 version.

Hewitt: I have a broad comment. On the initial list of drivers, you mentioned that the price of energy is really fundamental. Maybe on the energy management side of it you should go into more detail to include pricing demand. We kept coming back to the driver of energy efficiency as a least-cost resource. The various levels of pricing and how that impacts energy use is also important.

Nock: Another driver to add is the smart grid. A lot of metering is going on for demand response that could be used for energy efficiency as well.

Stephens: I don't get out much, I suppose. In the few cases where I have, I don't know that I've encountered a control system on a building that actually worked the it was intended, or encountered people at the building who actually knew if the system worked or not. Also, within ten years most of the systems are obsolete and can't communicate with the end-use stuff now being developed. The complexity, in the end, was not serving us well in part because we didn't even know if anything was working correctly, and we may never know. We may need to simplify things a bit or manage it in a different way. I'm not impressed with our achievements thus far in the face of these kinds of complexities.

Currier: this is where *my* car analogy comes in. Over the decades the cars have gotten better and more capable, while our buildings are becoming less capable while making use of many of the same kinds of technologies. How is it that we haven't yet developed buildings that can make the best use of the kinds of technologies in cars?

Stephens: I would disagree. All of the electronics features in my car died within three years, and the car still works. Maybe there are cars out there that are among the most expensive where the technology works and lasts longer than three years. So the fact is, the best cars might work, but the same technology might not be applicable for buildings.

Currier: You're right. Designing buildings is hard, and they're often not designed for the way that actual occupants use them.

Erben: One of the things that we also discussed was integrating better energy management system components into building operations so that the systems becomes a piece of what everyone thought about. Maybe simplification here is the key thing to focus on?

Livingood: We recognize these comments and agree. We tried to address them to some level. We recognize that there needs to be a paradigm shift in how controls work today. Today we're working from a "central brain model," but this is not terribly appropriate. Ultimately building controls and management systems will end up based upon a more distributed intelligence kind of framework, so that every device and sensor is aware of those around it so that it can control itself in an optimal manner to work well and use less energy.

Effinger: A big area of drivers that we didn't see in the original list provided was the group of business drivers—decreasing costs, increasing productivity, etc., so we integrated these ideas into a lot of our drivers.

Binus: The need for those kinds of drivers came out clearly in our industrial workshops as well.

Heating, Ventilation, and Air Conditioning (HVAC)

Smith: We had many of the same themes that the previous group had. We had six main categories that we dispensed with. We included reduced HVAC loads in buildings and a lack of properly-sized equipment. We don't currently have HVAC equipment that will work with the reduced-load buildings that we are designing.

Another driver was maintaining power quality while using direct current motors. From a utility perspective this is an important consideration.

Indoor air quality was also important. We discussed future equipment that will probably need to separate-out the heating and cooling elements of the air.

Stephens: The loads need to be separated.

Smith: Another major them is that the equipment we have today is fundamentally different in design from traditional HVAC systems. We're moving from centralized systems to zonal systems. Another theme was the transition of equipment design from a more complex, patched system to less complex systems.

Another theme was consumer demand for lower maintenance costs. Another is reduced first-cost of new systems—or the HVAC equipment that gets put into new buildings should be on par with the costs of heating and cooling buildings today, as opposed to a higher first-cost, which would be the case as we downscale the size of the systems.

Another them was determining how savings could be achieved. We discussed benchmarking, if appropriate, at the building model or at the end-use levels. There is also the reduced need for refrigerants with rising global temperatures. Another important driver was contractor interest in increasing profits.

Effinger: What about—when I was looking at these roadmaps ahead of time I was seeing a lot of complex systems, but what about the reliability of systems and the quality, especially of the packaged units?

Baylon: There was a certain amount of adjustment in the HVAC roadmap categories that we were given. We got rid of the Variable Refrigerant Flow roadmap altogether. More fundamental is the issue of increasing the quality of heating or cooling delivered. How do you get better, more efficient distribution and creation of heating and cooling systems? This is in contrast with refrigerant because with global warming you get a lot more refrigerant potential.

Fedie: We also talked about simplifying systems and moving heating and cooling around more efficiently. Also, related to the modeling point, if we're moving to performance benchmarking or codes, how do we get better models that actually represent the built environment?

Baylon: That's what our driver D39 means.

Petrill: Was there any discussion around quality maintenance? Other organizations have been ensuring some standards around quality maintenance and training in this area, did you discuss this as well?

Fedie: We got into that in one area involving predictive maintenance. The truth is, we're not doing a lot of maintenance on these systems, and we discussed what this has to do with training and commissioning.

Baylon: One other thing we did was add a category that wasn't there in the beginning, a Domestic Hot Water Heating roadmap.

Smith: This roadmap was among the suggestions from the earliest roadmapping sessions we had in 2009 and 2010, but somehow this particular roadmap disappeared from subsequent documents and discussions. We also talked about integrating HVAC and hot water heating as a way to simplify systems.

Binus: I think one of the regions that the hot water heating roadmap fell off was that, initially, this roadmapping process was focused regionally, and stakeholders determined that this was not an item important enough to the Pacific Northwest to warrant its own roadmap. It's nice to see it back in the Roadmap Portfolio, however, and we'll complete the roadmap at the Summit in September.

Higgins: I just want to ask if the HVAC roadmaps also capture conductive desk-based cooling and heating, such as mats that help keep people's feet warm while they're at their desks. This is a group of technologies that has to do with thermal comfort but that aren't HVAC systems necessarily, but I think it ought to be included somewhere.

Fedie: Along these lines, Levin mentioned "task HVAC" which would be like task lighting.

Marques: I wonder if there is a driver in the HVAC roadmaps involving the use of mixed-mode or operable windows?

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Baylon: We did add that driver to the list involving indoor air quality. But the emphasis was on dedicated outside air and not re-heating.

Marques: There is a separation between ventilation and heating.

Ander: With the Western Power Pool's focus on time-of-use rates, and the Federal Energy Regulatory Commission's interest in the maturity of demand response markets, what are the opportunities for utilities, aggregators, and others, particularly within the HVAC space, for the increased viability of [unable to record full statement]

Baylon: We are sort of biased in this region against spending a lot of time on air conditioning up here, but it does seem to us that it response well to load heating. Our bias here is on the region west of the Cascades.

Binus: Just remember that we're in the process of morphing the *Roadmap Portfolio* from a regional to a national effort.

Husted: A strategy that we're looking at at Puget Sound Energy is customers installing air conditioning where they weren't doing that before. We certainly need to look more closely at this, and how things might be changing in response to global climate change.

Binus: This touches on a whole category of technologies that we haven't yet included in this portfolio, such as demand response and distributed generation. We haven't included these categories to date because past participants were concerned that if we were to do so these technologies would swamp-out technologies related specifically to energy efficiency. There are some grey areas in the portfolio between energy efficiency and demand response / distributed generation because our approach has always been less about establishing strict boundaries and more about taking optimal advantage of participants' expertise. Things seem to be moving in the direction of including demand response and distributed generation in these roadmaps, however, including controls equipment.

Marques: If you draw the line at customer end-use technology, do demand response and distributed generation technologies still apply?

Smith: One prime example of a utility driver in this area is the need for storage.

Fedie: This has been a good discussion. Our group focused on producing and distributing heating and cooling, not how to shape or store it.

Ander: There may be synergistic opportunities here to do these kinds of things in conjunction.

Stephens: Solutions for that are going to differ regionally, based on climate. One of my favorite HVAC vendors experimented with this kind of thing in the Middle East, and was able to reduce load 45 percent just by installing different HVAC technologies. We need to do a better job—not just regionally but nationally—in learning from examples like these. It's often the case that emerging technologies in this country are proven and widely-applied technologies in Asia or Europe.

Erben: I heard a simple statement that resonates: Peak pricing is going to be a key driver for HVAC systems, whether these systems are cooling or heating. This is important.

Binus: It might be time to revisit the idea of including or continuing to exclude demand response and distributed generation technologies to see if we need these in this Roadmap Portfolio.

Baylon: This particular HVAC working group focused on the need to cut down or eliminate as much HVAC as possible through management of the load and equipment and, more importantly, to separate-out the systems to deal with cooling and heating separately. That's a more fundamental concern than peak load management and probably solves peak loads in a lot of ways. Ours was not an effort to do peak load management, it was an effort to get the impacts of space conditioning as low as possible.

Stephens: In Germany, they had eliminated the peak altogether through the widespread application of solar technologies. 25 percent of their power comes from solar energy. When energy use ramps up in the morning, it coincides with the increase in power that comes from solar, so rather than hit a strong peak it flattens-out through the day because of the coincidence of the sun and the loads.

Binus: I would like to get one more comment into the minutes. As this effort moves forward to attract national experts, we don't have an appropriate steering committee to help us work through issues such as the line between energy efficiency and demand response. Regionally we do have such a steering committee in the Regional Emerging Technology Advisory Committee (RETAC), but we don't have such a body on the national scale. I need to work with people to address this.

Livingood: If we talk about twenty years out, there's no better way to address HVAC than radiant heating and cooling. There are capability gaps in this area.

Baylon: We thought that integration of radiant systems with [unable to record complete statement] outside air, they go hand-in-hand, but without that, you're pretty much lost. We don't have a distribution system to deal with integrated ventilation systems along with HVAC.

Livingood: What integrated package is incorporated?

Baylon: One of the best options is radiant heat, not the *only* option but the best. Zonal heating and cooling is where the focus is.

Fedie: In the area of capability gaps we discussed technologies that can use radiant, high-efficiency working fluids. We didn't discuss these as drivers but as capability gaps.

Livingood: There are examples of good uses of these kinds of technologies, even in the U.S. Southeast.

Mathew: On that note, we've talked about a lot of interesting technologies. Did you talk about the inherent inertia in the HVAC industry? About ways to overcome the risk perception in the industry? If you look back twenty years, we haven't really made a dent in installing more efficient technologies that were developed at that time. One example is variable air volume (VAV), and we haven't made much progress in installing this

Ayoub: We often came down to the issue of training.

Volkman: And we considered this more of a driver than a capability gap.

Binus: Anything else? Ok, I think that caps the discussion, so let's move on to lighting.

Lighting

Rehley: There's a few no-duh drivers that came up for us that we did not see in the initial list. Energy efficiency as a least-cost resource and demand response were drivers that we added. After that, human interactions was another important driver, such as the connection of lighting quality to human health, productivity, and satisfaction—we can't do anything without considering these drivers. We listed them.

Another important driver was the consideration of hazardous materials, such as the use of mercury and lead that are in light emitting diodes (LEDs). This is an issue that the industry hasn't addressed yet.

One of the biggest drivers is the transition to digital. In twenty years, do you all really think that you'll be able to buy any other light bulb than LEDs? The trajectory of this technology in terms of lumen output, costs, and other factors makes it apparent that this is the trend. There are a bunch of things connected to this trend, however, such as integration of this technology with other technologies. There are lights that have speakers integrated with them wirelessly. There's also the issue of the miniaturization of sensors—we're seeing this in some commercial products now with costs less than a ballast to a fluorescent light.

The health effects area includes lighting that can change color temperatures throughout the day such that it emulates natural light. The transition to digital opens up a whole bunch of doors. And the miniaturization of lighting technologies

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brings in many more applications, such as lights at the end of the dentist drill that makes it unnecessary to use those large traditional overhead dentist lamps. Then there's organic LEDs (OLEDs) as well. I think they'll be painted on just about everything one of these days.

Industry inertia and interest levels are also important drivers. The digitization effect might face barriers in supply and use. Utility programs are set up as one-to-one replacement of lighting technologies, but how does this work with the process of miniaturization when one-to-one replacement no longer applies?

Another important driver is greed. Anything that brings more value and more profit, comfort, and convenience is naturally going to be adopted. To the extent that a utility's program is connected to this, it will spur adoption.

Our gaps were divided into six groups. Here are some highlights of our conversations: We had a General Lighting roadmap, and it was hard to get our arms around this roadmap. We think that it should be re-named "Lighting for Human Factors," but we can discuss this more a bit later. In this roadmap we looked more at optimizing design, addressing health issues, and finding that there is much research needed in this space.

Next was the Luminaires roadmap. We didn't add a lot to this discussion, except for a driver that says how to transition from existing luminaires to where the technology needs to be, such as an LED designed specifically for T8 fluorescent fixtures.

Then we got into the Task Ambient and Lighting Controls roadmaps, which we kind of lumped together. What we added was new research around getting daylighting deeper into buildings, or utilizing daylighting that does not come from a constant source. For example, the lighting source from the sun changes over the course of the day, so there's need for technologies that compensate for this light shift from skylights. We also added more about the hardware of daylighting than we did daylighting controls.

We did spend a lot of time on lighting controls. The old roadmap doesn't have a lot of detail in this area, so we tried to address that, such as, if you get into color shifting lights, how do you control that? It's going to need more control than "on," "off," and "dim." Do you want LEDs to do the same thing that incandescent lights can do, such as color shifting, or not? If things are going to happen automatically through controls, do the controls respond the way that people want? If not people will disable the controls and not use them.

On the Solid State Lighting roadmap we added almost nothing, because everyone's been looking at this for quite a while.

There was general agreement in our group that there are huge levels of work to do, that things are getting complicated, and that it won't be easy.

Baylon: Why not make the lighting roadmaps more simple, and focus on less control and more on efficiency and efficacy?

Rehley: Because the next twenty years may not go that way. Say we go to digital technologies and we have entire walls that are also lights, and that lighting is integrated with televisions and speakers, maybe even human health sensors. The notion we were working with was that on the horizon there are a lot of things that appear to be coming together that could lead to more consumption instead of less, and that we need to find ways to ensure that these products are as energy efficient as possible. Also, lots of drivers in this area are linked to human health.

Ander: Are you talking about the research on circadian rhythms and human health? I don't know if everyone here has heard, but there was a recent medical paper on the negative impacts upon circadian rhythms from LED streetlights.[1]

Rehley: The important point here is that the more we move to different lighting technology, it gets more complicated as the technology becomes more integrated into other products and systems.

Thomas: It's more efficient, but you're using more.

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[1] See, for example, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, "Late at Night: The Latest Science," Nov. 2010, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_whitepaper_nov2010.pdf.

Baylon: I don't quite understand what the lighting group was looking at.

Rehley: For example, if you design a light that is *both* more efficient *and* more healthy, then that's one thing. But if it comes down to a question of designing a light that is *either* more energy efficient *or* more healthy, that's different.

Hewitt: We're seeing a lot of innovation in LEDs. That's a lot different than the situation in HVAC technology—the y have an Oldsmobile business model. Lighting is different, and not all innovation is going to be about efficiency. We need to work within that paradigm. We're not suggesting that we don't do things that take us away from energy efficiency, but that we keep the other kinds of innovation in mind as well and be prepared to react to that.

Rehley. The example might be the innovation in televisions when the plasma screen technology came around. This technology was very high in energy use, and the utilities tried to manage the load growth that they were seeing as a result of the widespread adoption of the technology.

[Various participants expressed that this was a matter of synergy—looking for opportunities to work within the industry to help bring about innovation from manufacturers that is as energy-efficient as possible.]

Baylon: That's an important insight, that we don't have the potential problem of the innovation leading us down the anti-energy efficiency path.

Higgins: It's also important to consider skylights, solatubes, and other kinds of daylighting technologies that penetrate building envelopes.

Hewitt: Daylighting systems in our roadmaps centered more on controls, so we spent our time on how to get daylighting deeper into buildings, and also to some extent on window glazing. It was more about lighting spaces with daylight instead of electric light.

Williamson: One of the more interesting comments made in our recent lighting Technology Advisory Group (TAG) was that if we all focus too much on decreasing lighting technology costs, manufacturers might respond by compromising on quality.

Marques: On that note and combined with the greed driver, do we really think that the Department of Energy projections on kW reductions per lumen[2] will really happen, or that the companies will reply that they have to sell you more than one light bulb in your lifetime? Are costs going to get that low, or should we focus on other efforts?

Rehley: We did talk about that. This is a risk area, and utilities must consider what the landscape might be twenty-five years out. Maybe it will be once every five years that the companies will have us change-out our light bulbs, particularly if they have integrated features such as speakers and sensors. It might be like cell phones are today: people change-out their cell phones even when they don't need to just because they want the latest gadgets and functionalities.

Kelleher: Again, it comes down to synergy.

Electronics

Hardy: The main drivers in the electronics industry are device proliferation, and also increases in Internet traffic such as from streaming video. Electronics have been the fastest-growing share of energy consumption increases and impacts on building plug loads. It's hard to predict how individual electronic devices are used. As devices get more efficient, they also get bigger, and therefore use more energy. Innovation is a major driver in this industry, but it is hard for utilities and regulators to keep up with the pace of change. Laws made now might not be applicable ten years later. It is also a global industry, which is hard to regulate at the state level. We need to act in close coordination at the various levels of jurisdiction and interest, but this is hard to do.

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[2] See, for example, U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, "Energy Savings Potential of Solid-State Lighting in General Illumination Applications 2010 to 2030," prepared by Navigant Consulting, Inc., Feb. 2010, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_energy-savings-report_10-30.pdf.

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We've also go Mohr's Law that computing power will double every two years and Koomey's Law that states that energy consumption for electronic components will be cut in half every two years. There are a tremendous number of standards for electronic equipment, covering thousands of component interface standards as well as legacy standards such as national standards that are hard to revise and change quickly.

There is a need for backward compatibility with the legacy standards, and companies need to do better design to ensure this compatibility. Also, there are a lot of systems that were designed to be in the always-on mode, which interferes with set-top box design in the present.

Another major driver is the trend of "the four anys": consumers wanting their electronic devices to provide any content on any device anytime and anywhere. Examples are smart phones, iPads, and the like.

There is a driver for seamless integration between technologies, such as Apple has developed with Apple TVs and iPhones. As vendors such as Apple show this kind of integration, more people will want it.

There is also a shift to having more networked devices. What this means is that the traditional state of stand-by for most devices has changed to a need for constant network connectivity even when these technologies are not on. There is work being done globally in the area of developing standards for this, but more work needs to be done in the U.S.

Another important driver is the move toward cloud computing that enables less wasted power in the form of tens of thousands of individual devices being left on. The energy utilization at data centers is optimized, in comparison to the distributed devices, because it is centralized. There is also an incentive for cable and Internet provider companies to get more efficient in their server rooms and data centers. They have a plan, called the Smart Energy Management Initiative (SEMI), to address this and reduce energy consumption.

Another driver, one which the SEMI initiative is addressing, is that there is a low utilization of network hardware. This hardware is always on but is not often used to its optimal capacity. The industry knows this and they are trying to get their network backbone equipment back up the power scale. EnergyStar is working on standards that encourage standby for end-user equipment.

What do we do about all of these drivers? Are they gaps or opportunities? One of the big ones is power scaling—using the appropriate level of power when the equipment is on. There are different kinds of "appropriate" for different kinds of devices, such as game consoles and video streaming. Also, standby is not just standby anymore, but there are now multiple levels of network connectivity, or even connections to smaller home networks. We need to encourage manufacturers to develop this and we also need to think more about it as utilities.

Context awareness is an important arena for the development of energy efficiency technologies, such as embedding occupancy sensors into a television that is connected to the Internet and streaming music—when someone isn't in the room to see the screen, the screen could dim. We also need technologies that can update power consumption on a millisecond level, such as between keystrokes when someone is typing on a computer.

Number two is the shift to the cloud. This is an active trend. We can do some things to encourage the shift to the cloud. The pay-per-view television industry would gladly get rid of every digital video recorder (DVR), because this equipment fails every three years or so, and the companies have to send a technician out to replace the units. Comcast, for example, spends $2 million per year to replace set top boxes. They could easily deliver their content through the cloud and thereby not need DVRs. One of the leading barriers to this is the legal environment for copyright law, which won't allow streaming of video through the cloud; we need someone to work with legislators on this to get this changed.

Another regulatory barrier is the Federal Communications Commission (FCC) has a regulation that cable companies must send a person out to the site every time a customer disenrolls from cable television service. The FCC is also trying to empower people to use broadband Internet by changing requirements to maintain full bandwidth of broadband when only a slice of it would be necessary for monitoring purposes or other minimal uses.

This all has to do with system-level thinking: Is it better in terms of energy efficiency to have all of these DVRs out there, or is it better to have cloud-streamed video? Our policy would focus on unit-level assessments.

Binus: I want to make sure that we have time for comments, so please wrap this up in three to four minutes and we'll have about five minutes of questions.

Hardy: Ok, we also looked at the main components of electronics. The mobile and data centers are leading innovation, but this doesn't always make its way to individual users and desktop systems.

We talked about the importance of power factor and how optimizing this can save a significant amount of energy system-wide.

We also looked at direct current (DC) power.

Harris: We talked a little about DC power and distribution. The opportunity here is that you go through all of these convergence steps. EPRI has done some research in this area. But we have such a problem with infrastructure where we need to make sure that power supplies can handle DC. Such as a present-day systems that can handle anywhere in the 100- to 150-volt range, or in the 50- to 60-watt range, wouldn't it be good to have a similar system for DC where the power supply of a given technology could know if it was DC or AC, and react accordingly and automatically. EPRI's work in this area shows that this is a viable area of research and an important gap to fill.

Panzer: It is also important to get sensors into electronic devices to focus on human behavior patterns and use patterns.

Baylon: If I were to summarize what you said, the capability gaps in this industry concern how the utility industry might best play defense, in the face of constant innovation and growth of products? We don't have much of an impact on the products themselves, but we could face problems in how they interact with the grid?

Panzer: There are some opportunities for influencing the industry, I think.

Baylon: What is their incentive—because the industry wants to make us happy?

Panzer: One example that is good in this area is the work that EnergyStar has done.

Livingston: If I could push back a bit I would say that you're right, Dave, but doesn't your statement apply in all of these product and service areas? It seems like a broad concern that applies across the board.

Harris: I feel like standards is even more important here than in other areas. One thing that we skipped over was the work going on to establish Internet Protocol Version 6 (IPv6), which will set international standards for the next generation of electronics. If we could influence the standards that get ste on component and energy management protocols, this will trickle down to every single component being compliant and we can at least know what the states are of individual systems. There are some drivers that we can get ahold of if we get out ahead on this.

Baylon: When you say "we," whom do you mean?

Harris: Utilities, regulators, and others of us in this arena.

Reddoch: I look at this a bit differently. Electronics is different somewhat in the way that lighting is different from the other product and service areas we're discussing. Electricity in electronics and lighting is an enabler that is leading to innovation in functionality. Our response is to understand how we can deliver this innovation most efficiently. We have had enormous success in browbeating and code making to make companies more energy efficient.

Livingston: Dave's comment was great. What's fascinating about the electronics industry perhaps more than the others is that in electronics heat is the enemy of a given device. One of the reasons why the set top box industry is open to energy efficiency is that it can't stand the heat.

Panzer: Your point about why they might want to work with us is that this industry has for a long time moved toward developing more hardware, and recently has become more interested in developing more software. I think that we'll see more integration through the cloud and networking and less focus on hardware in this industry. Players that want to continue to look at the past and continue to focus on producing hardware devices while consumer tastes change will

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find that this approach cuts into their market share while other players are doing more to integrate approaches and lower their costs.

Baylon: I meant my questions as a rhetorical point.

Harris: We did talk about context awareness. There's a link here to energy management systems: If we're able to get these devices to have integrated sensors that will monitor power use, such as building-level control systems that tells us about energy use, then we need component-level controls to modulate consumption.

Higgins: Having control at the plug instead of the device is important. The trend is for building standards to be able to have space- or tenant-level isolation of loads for better energy management [Clarification note from NBI's Heather Flint Chatto: "this was in the context of the CBRE study that real time energy use feedback due to sub-metering per tenant was the most significant contributor to the energy savings they measured in their portfolio"].[3]

Marques: On the issue of plug load, usually when dealing with this issue the consumer market dominates, but when we talk about plug loads, once lighting technology gets more efficient, then the plug load rises in relative terms to become the biggest load. Maybe we need to have a new technology area in the Roadmap Portfolio focused on plug loads.

Binus: Let's be sure to bring this up during our next discussion on the portfolio reorganization.

Fedie: Similar to Gregg's comments regarding HVAC shaping and power quality, there was a lot of conversation in our group about plug loads, but maybe there is also an opportunity for demand response and understanding how we can shift loads. Cloud computing might help shift power away from peak areas.

Rehley: Did the electronics group look at what the product and service area looks like in twenty years?

Hardy: Yes, and what it will look like is nearly universal wireless access. It's hard to know if there will be a proliferation of devices or device centralization. Intel Corporation has been trying for years to get personal computer centralization, but it has not happened.

Livingston: Another nightmarish side to consider: In about 1999 a New York architect did a video of a home in which all of the non-exterior facing walls were video screens. This was his vision of the future.

Reddoch: Once you look at our proposed changes in the research agenda, you'll see that we've changed the titles of the roadmaps and aggregated some. I was involved in Round 1 of this work years ago and was surprised at how antiquated the information was just over the past three to four years. We've moved from more boxes in the roadmaps to fewer boxes, and put more software in there.

Task 5: Presentation & Discussion on Proposed Revision to Roadmap Portfolio Organizational Structure

Binus: Now let's switch to Task 5 where we'll be able to get some feedback on possible changes to the organizational structure of the Roadmap Portfolio. As a planning team we had WSU come up with a draft set of changes and then have reviewed these changes internally. Now we'd like to get your input on these to help us refine them.

[3] The CBRE Group, Inc., has collaborated on a multi-year green building study with University of San Diego's Burnham-Moores Center for Real Estate and McGraw-Hill Construction titled "Do Green Buildings Make Dollars & Sense?: An Analysis of Operating Costs, Worker Productivity, and the Benefits of LEED Certification in a Commercial Office Portfolio." The 2011 findings of this study (version 3.0) found that "The 2011 phase reinforces earlier findings that demonstrate sub metering of utilities for tenant space reduces energy costs by 21% on average"; see http://www.cbre.com/EN/aboutus/MediaCentre/2011/Pages/10062011.aspx.

Penney: To provide just a brief overview of the changes that we've suggested, as you are comparing the original portfolio organization with the revision suggestions, you'll see that the HVAC and Lighting roadmaps weren't changed much. We did do significant changes in the Building Design / Envelope roadmap, and the Electronics roadmap we really trashed. As you're discussing these changes, refer to the definitions of each one in the pages that follow for more information.

Building Design / Envelope

Manclark: My first reaction to the roadmaps in this product and service area is that I think the challenges between retrofit and new construction are big enough that we might want to retain the separate paths.

Johnson: I agree.

Pengilly: When we were trying to decide how to look at this, we decided that there are enough differences that we'd like to keep them separate. All of the retrofit roadmaps applied to the new construction roadmaps, but not necessarily vice-versa.

Johnson: I see four categories here: Commercial and Residential New Construction as well as Commercial and Residential Retrofit.

Currier: There might also be a useful distinction between multifamily and commercial.

Binus: Ok, great. I'd appreciate any other thoughts, and also written comments on all of these after today.

Gleeson: Another important consideration is financing. I know that this doesn't involve technology, but to go back to my apples-to-apples comment, if someone is doing building construction in multiple states, there is a distinct need for commonalities.

Zoeller: You have building design and envelope indicated here, but the roadmaps don't actually have much in the way of design.

Binus: Are you saying that we need a specific roadmap on design for residential and commercial buildings?

Zoeller: Yes, I would suggest that.

Baechler: I would add to that whole building integration

Binus: So you're saying two roadmaps, one on whole building integration and one on design?

Baechler: No, just one that integrates design and integration.

Baylon: I wasn't clear about what was just discussed.

Zoeller: I just thought that there's no roadmap specifically for design. What is the roadmap for this area—should there be a category that fits into the portfolio specifically on design?

Zeiger: In working to create this draft reorganization, our approach was to include design with the Transformational Approaches title.

Binus: Maybe we include design within the definition of transformational approaches, and thereby incorporate design more explicitly that way?

Callahan: Design and envelope shouldn't be combined, they are two distinct areas.

Zoeller: At least in the work we're doing in the area of retrofits, a lot of what we're running in to regarding insulation is air quality and ventilation.

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Baylon: We did spend time on that in our HVAC group, and you're right, they're not separate questions.

Hewitt: The Transformational Approaches category definition could be limited to building design, and take out envelope-related topics altogether. And then when you get to the areas that we covered in lighting, maybe windows belongs in a roadmap titled something like "Fenestration Design and Windows Technology" which will include such things as shading devices. All of these kinds of things are in the architect's area, and it would seem to make more sense.

Roberts: I would recommend taking the word "Design" out entirely. It doesn't necessarily apply.

Hewitt: How about "Integrated Strategies?"

Sensors, Meters, & Energy Management Systems

Mathew: I have a point of clarification for this product and service area: Among the first two categories in the suggested reorganization, is the first dealing with hardware and the second dealing with software?

Binus: Rob, can you respond to this question?

Penney: The services are those that take your smart meter data and slices and dices the data.

Zeiger: It's a third-party service, and that includes both hardware and software.

Effinger: I feel like there's a lot of overlap with all of these areas and there's not a clear bucketing structure here.

Binus: What do you mean when you say "all of these areas?"

Effinger: Within the Sensors product and service area roadmaps. What I'm proposing is somewhat roguish: A re-bucketing of all of these roadmaps into the following: meter-level devices, because connecting to utility meters is different with different protocols and equipment; up-leveling a little we get to energy management systems that are at the device to the end-use level; another level up we get to building-level management systems and communications systems. And then having another bucket for services that overlaps with all of these; next there will be another bucket that includes the customer's level. And then there is the communications thread that cuts across all of these.

Callahan: I would agree that the existing set isn't clear to me.

Binus: What do you mean when you say "existing?"

Callahan: The set of proposed revisions. I think we should put some more thought into this. One more thing in the title is that "energy management systems" might instead be just "energy management," to include approaches as well as systems.

Mathew: Doesn't that get outside of technologies?

Binus: We'll keep the technologies in the roadmaps, but we'll provide space in the March 2013 version to include non-technical aspects that stakeholders think is important so that we don't get too myopic in thinking that technology is the only answer to something.

Livingood: I think that going with the title "Energy Management" we can continue to focus on technologies but the title will give us the flexibility to allow for paradigm shifts.

Marques: I kind of like them as they have been proposed in the revision document.

Binus: Maybe what cuts across all of them are human factors. Part of this is behavioral, but part of it is human factors such as usability; it has to do with design.

Effinger: And how people make decisions. Do we really even understand how people make decisions related to energy management?

Pengilly: There is a huge marketing component here.

Reddoch: Because marketers know how people make decisions.

Electronics

Hardy: The categories are consistent with how a lot of other studies have broken plug load down, such as the Department of Energy and the California Energy Commission and others. I have a couple of questions: What about water heating, refrigeration, and cooking? Do these fit under this category?

Ayoub: Is refrigeration under Appliances? And cooking as well?

Zeiger: Commercial cooking is different.

Hardy: On all three of those, Fraunhofer did a recent study in this area. If we do expand the scope we should call this roadmap “Miscellaneous Loads” instead of just plug loads.

Penney: Refrigerators are under the “Appliances” roadmap, and cooking should be under this as well.

Baylon: There is a delusion that commercial refrigeration is somehow under the category of plug loads, but it’s not.

Reddoch: Rather than trying to cut so thin, maybe we say something like “Residential Devices” and “Commercial Devices,” and list the devices under them, rather than trying to specify items. The category covers all of the devices.

Marques: In a similar vein, we have to separate commercial from residential appliances. Commercial refrigeration and I would also say commercial kitchens.

Binus: We also have an industrial food processing roadmap that does include some aspects related to refrigeration.

Marques: If there is a distinct step from residential to commercial refrigeration, there is definitely a step from commercial to industrial refrigeration.

Callahan: I’m having difficulties with the “Plug Load” designation. That doesn’t fit well. Is a water heater part of plug load? Are servers plug loads? And we’ve lost electronics entirely, and that’s a big category. Our biggest, by far, a transformative thing. Electronics is bigger than “Miscellaneous Loads.”

Livingston: First of all, it is important to note that even though we’re at BPA, food service and domestic hot water technologies have significant gas systems involved, so they don’t belong in this roadmap. What we’ve been doing today is looking at interconnectivity, and right now there’s a strong data center component. Right now there’s a center of gravity, and I think we need to do more work, so I ask for better guidance from the subject matter experts here.

Binus: Would it be helpful if I send everyone a copy of the Roadmap Portfolio reorganization document so that people can review it and get more substantial comments back to us?

[Everyone thought this was a good idea.]

Williamson: How about posting it on Conduit so that you can all see the comments?

Binus: [Explained to the group that Conduit was an online tool for networking and sharing among Pacific Northwest folks involved in Energy Efficiency. https://conduitnw.org/Pages/Welcome.aspx]. This might be a good way to facilitate the conversation. By a show of hands, how many people here are on Conduit? [About half of the attendees indicated “yes.”]

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Ayoub: If you end up doing it this way, please send out instructions for accessing it.

Hardy: One thought is that you should go through the Fraunhofer paper as it lists all of these categories that we've been talking about.

Binus: Could you please forward it to us?

Hardy: Yes. Another thing we went through were energy savings opportunities. As I look at the proposed reorganization, some roadmap categories refer to market segments, others to innovative behavior techniques, but these are different kinds of categories. It looks logical, but could there be more consistency in how we break these down?

Livingston: In our group, we modified and combined some of these roadmap categories. Did other groups do this? [Some folks indicated "yes."] I'd like to see that work get sent out so that we can all see what these revisions look like.

Lighting

Hewitt: One thought is that we spent a lot of time talking about using nickel words such as human-centered environment. Optimizing design implies tools that would enable this, and that's an integrated thing on the lighting side that might be important. Also, the way we look at daylighting could be moved to the "Transformative Approaches" roadmap, and maybe that's where it should be.

Currier: Dave, were you not seeing that in the definition of the "General Lighting" roadmap? It may not be in there exactly the way you describe it, but it does seem to be there.

Hewitt: I think there might be a few too many things in the "General Lighting" roadmap description.

Rehley: What if we changed the title to "Lighting Design" as a way to focus it on balancing sources, controls, etc.?

Livingston: That fits the definition pretty well.

Pengilly: Is there a separate category for industrial lighting?

Binus: Not yet. We've worked on lighting within our industrial food processing roadmap, but this has much to do with lighting that heats refrigerated spaces. What you're suggesting is a part of a whole new frontier of roadmaps to be made.

Heating, Ventilation, and Air Conditioning

Baylon: Where did this come from? It doesn't look at all like what we started with or where we finished.

Binus: We asked our colleagues at WSU to put their mind to this reorganization because we've found that the current portfolio organization we've been using since 2009 is getting a bit long in the tooth. It's worked for us for this long but we've also recognized weaknesses, so we want to revise it to make it more applicable and useful. Our plan is to get your comments on it today, wrap these into a new version to get comments on during the September Summit, and then apply this new organizational structure to create the March 2013 Roadmap Portfolio.

Baylon: As I look at these two and compare them, I'm wondering which one makes more sense?

Binus: While the existing framework has been helpful out of the gate, there are issues with it. We wanted to start some dialogue on this today, so we brought this draft to that people can react to it and we can get these reactions documented.

Baylon: That's worked pretty well! First thing is, gas cooling shouldn't be on there as it's the least efficient way to do cooling. Second, and an important point, is that the ventilation systems should be broken-off from the heating and cooling systems. Ventilation wasn't explicitly in any of the other roadmaps, and is not really represented here either.

Petrill: It just happened to be covered in the new brilliant work we did here today!

Baylon: The order is weird but let's say that it works well. I don't know why evaporative cooling is a separate category.

Stephens: Maybe we should have a roadmap on non-traditional cooling, broadly construed?

Fedie: Like we have in the case of the Fraunhofer study, we do have a common reference that we can use. This is the ASHRAE reference guide that lists their categories, and we can use this to base our organization off of.

Binus: Everyone's comments here are very helpful, concrete suggestions.

Baylon: I would add domestic hot water heating, take out gas cooling, and probably take out evaporative cooling. I'm not sure what "advanced refrigeration" means—

[a participant explained this but the information wasn't captured]

Baylon: Ok, so leave that in. Regarding motor-driven systems, the use of variable speed systems and technologies is the important point here, not that they are motors, so the roadmap should at least say "Variable Speed."

Stephens: I would argue that instead of "Variable Speed" I would add "Variable Capacity" to include water and air.

Baylon: Even add non-air distribution systems; we have this on various roadmaps but not on a separate roadmap unto itself.

Binus: Should we call it "Efficient Distribution Systems?"

Baylon: That's find.

Stephens: There's nothing here regarding systems integration and optimization.

Baylon: Our group discussed that we should include this, as a separate category.

Volkman: There is a list in the back, in the definitions section, that includes distribution systems, but this was not in the diagram.

Binus: That's my bad because I must have missed it when I transcribed Rob's work.

Volkman: Innovative distribution systems would be a stand-alone roadmap.

Thomas: In terms of overall roadmaps, building design and envelope got smaller, HVAC got bigger. Is there general consensus on how people like broader categories or specific categories?

Binus: From a roadmapping perspective, it's better to zero-in on specific technologies, but that's logistically difficult. So, we're finding a balance between the broad and the specific. Ultimately, we'll create a new system and some people will like it and some won't but we'll have to agree on it and move on. Also, the next iteration will be stronger than the last.

Effinger: How in the roadmap—in particular HVAC—do dual systems come in to play? For example, data center heat recovery to heat domestic water?

Binus: Waste heat recovery is one of the areas that we really want to add to the portfolio.

Effinger: Other examples include cross-cutting between, say, lighting and HVAC.

Binus: That's a tricky question.

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Mathew: Whatever new organizational structure we come up with, if there are cross-cutting technologies we can just put an asterisk in the roadmap and direct people to the other roadmap in which the technology characteristic is featured.

Fedie: And then there's a struggle with how to break it down when we come to applications. The ASHRAE organizational structure includes a good example for the HVAC area.

Petrill: One more thing: Because we're nationalizing this, we need to add dehumidification technologies that are very important in other areas of the country.

Marques: Is this meant to be exhaustive, and then there's a prioritization process next? Like with HVAC, there's already more energy-efficient technology out there from twenty years ago that is not widespread in the market yet. What do we do about this?

Binus: That's the perfect seque to our next task . . .

Appendix A9:

National Energy Efficiency Technology Roadmapping Summit (Sep. 24–27, 2012)

The National Energy Efficiency Technology Roadmapping Summit convened in Portland, Oregon, September 24–27, 2012, with a preparatory workshop held August 8. Planning and implementing this event involved close collaboration among the Bonneville Power Administration, the Electric Power Research Institute, Portland State University Engineering and Technology Management Department, Washington State University Energy Program, and the Northwest Energy Efficiency Alliance. Summit participants included government entities, national laboratories, academic and other research institutions, public and investor-owned utilities, vendors, non-profit organizations, and others. (Names of Summit workshop participants have been integrated into the list on the preceding pages.)

Subject matter experts volunteered their time to update and expand energy efficiency technology roadmaps within the residential and commercial sectors. They further strengthened the roadmaps by articulating key research questions for most R&D programs listed in the *Roadmap Portfolio*. In so doing, workshop participants helped refine a resource used to optimize research and development investments by limiting redundant spending and identifying opportunities for inter-organizational collaboration.

In conjunction with the roadmapping workshops, Electric Power Research Institute staff organized four full days of expert panel presentations on cutting-edge technologies. The two-fold purpose of these presentations was: 1) to convene a group of expert speakers to provide brief and informative highlights and overviews of noteworthy research and development efforts; and 2) to provide a venue in which national experts could network with one another, share ideas and achievements, and gain inspiration and insights that could be applied in the corresponding roadmapping workshop.

Contained in this section of Appendix A is the Roadmapping Summit agenda and presentation schedule, and the following sections contain the agendas and minutes of each roadmapping workshop.

Summit presentation videos and materials can be found at http://online.etm.pdx.edu/bpa_summit/home.html.

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NATIONAL ENERGY EFFICIENCY TECHNOLOGY ROADMAPPING SUMMIT

September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

SUMMIT SCHEDULE

Monday, September 24

7:30-8:00	Continental Breakfast + Coffee	Cascade Ballroom, 2nd Floor
8:00-9:00	**Welcome, Orientation, & Opening Remarks** ▪ **Karen Meadows,** Bonneville Power Administration Energy Efficiency ▪ **Jeff Harris,** Northwest Energy Efficiency Alliance ▪ **Omar Siddiqui,** Electric Power Research Institute ▪ **Joshua Binus,** Bonneville Power Administration Energy Efficiency	**Cascade Ballroom, 2nd Floor**
9:00-11:30	**Panel Presentations: Lighting**	**Cascade Ballroom, 2nd Floor**
	Roadmapping Workshop: Sensors, Meters, Energy Management Systems	**Adams / Jefferson Room, 1st Floor**
11:30-1:00	**Keynote Address + Buffet Lunch** ▪ **Dr. Arun Majumdar,** Former Director, U.S. Department of Energy, Advanced Research Projects Agency–Energy (ARPA-E) ▪ **Steve Wright,** Administrator, Bonneville Power Administration	**Cascade Ballroom, 2nd Floor**
1:00-5:15	**Panel Presentations: Lighting**	**Cascade Ballroom, 2nd Floor**
	Panel Presentations: : Building Design / Envelope – Commercial Whole Building Transformational Approaches	**Sellwood / Ross Island / Morrison Room, 1st Floor**
	Panel Presentations: : Building Design / Envelope – Residential Whole Building Transformational Approaches	**Broadway / Weidler / Halsey Room, 1st Floor**
1:00-5:30	**Roadmapping Workshop: Sensors, Meters, Energy Management Systems**	**Adams / Jefferson Room, 1st Floor**

BONNEVILLE POWER ADMINISTRATION | EPRI ELECTRIC POWER RESEARCH INSTITUTE | neea | WASHINGTON STATE UNIVERSITY EXTENSION ENERGY PROGRAM | Portland State UNIVERSITY ETM

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SUMMIT SCHEDULE (CONTINUED)

Tuesday, September 25

7:30-8:00	Continental Breakfast + Coffee	Cascade Ballroom, 2nd Floor
8:00-8:30	**Welcome & Orientation** ▪ **Joshua Binus,** Bonneville Power Administration Energy Efficiency	**Cascade Ballroom, 2nd Floor**
8:30-12:00	**Panel Presentations: Building Design / Envelope**	**Cascade Ballroom, 2nd Floor**
12:00-1:00	Buffet Lunch	Cascade Ballroom, 2nd Floor
1:00-5:00	**Panel Presentations: Building Design / Envelope**	**Cascade Ballroom, 2nd Floor**
8:30-11:30	**Roadmapping Workshop: Lighting**	**Adams / Jefferson Room, 1st Floor**
11:30-12:15	Plated Working Lunch (delivered to room)	Adams / Jefferson Room, 1st Floor
12:15-5:00	**Roadmapping Workshop: Lighting**	**Adams / Jefferson Room, 1st Floor**

SUMMIT SCHEDULE (CONTINUED)

Wednesday, September 26

7:30-8:00	Continental Breakfast + Coffee	Cascade Ballroom, 2nd Floor
8:00-8:30	**Welcome & Orientation** ▪ **Joshua Binus,** Bonneville Power Administration Energy Efficiency	**Cascade Ballroom, 2nd Floor**
8:30-12:00	**Panel Presentations: HVAC**	**Cascade Ballroom, 2nd Floor**
	Panel Presentations: Electronics	**Sellwood / Ross Island / Morrison Room, 1st Floor**
12:00-1:00	Buffet Lunch	Cascade Ballroom, 2nd Floor
1:00-5:00	**Panel Presentations: HVAC**	**Cascade Ballroom, 2nd Floor**
	Panel Presentations: Electronics	**Sellwood / Ross Island / Morrison Room, 1st Floor**
1:00-2:45	**Panel Presentations: HVAC**	**Weidler / Halsey Room, 1st Floor**
3:30-4:45	**Panel Presentations: Electronics**	**Weidler / Halsey Room, 1st Floor**
8:30-11:30	**Roadmapping Workshop: Building Design / Envelope**	**Adams / Jefferson Room, 1st Floor**
11:30-12:15	Plated Working Lunch (delivered to room)	Adams / Jefferson Room, 1st Floor
12:15-5:00	**Roadmapping Workshop: Building Design / Envelope**	**Adams / Jefferson Room, 1st Floor**

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SUMMIT SCHEDULE (CONTINUED)

Thursday, September 27

7:30-8:00	Continental Breakfast + Coffee	Cascade Ballroom, 2nd Floor
8:00-9:00	**Welcome, Orientation, & Closing Plenary** ▪ **Ellen Petrill,** Electric Power Research Institute ▪ **Ryan Fedie,** Bonneville Power Administration Energy Efficiency ▪ **Joshua Binus,** Bonneville Power Administration Energy Efficiency	**Cascade Ballroom, 2nd Floor**
9:00-11:30	**Roadmapping Workshop: HVAC**	**Adams / Jefferson Room, 1st Floor**
	Roadmapping Workshop: Electronics	**Roosevelt Room, 1st Floor**
12:00-12:45	Plated Working Lunch (delivered to room)	Adams / Jefferson Room, 1st Floor
	Plated Working Lunch (delivered to room)	Roosevelt Room, 1st Floor
12:15-5:00	**Roadmapping Workshop: HVAC**	**Adams / Jefferson Room, 1st Floor**
	Roadmapping Workshop: Electronics	**Roosevelt Room, 1st Floor**

NATIONAL ENERGY EFFICIENCY TECHNOLOGY ROADMAPPING SUMMIT

September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

LIGHTING PANEL PRESENTATIONS

Monday, September 24, 2012 | Cascade Ballroom, 2nd Floor

The corresponding roadmapping workshop is scheduled for Tuesday, September 25

Panel 1: Lighting Controls — 9:00–10:25

Technologies and design approaches to improve the effectiveness and usability of lighting controls to minimize energy use while maintaining good quality lighting, including occupancy and photo sensors, dimming, daylighting controls and bi-level adaptive lighting approaches.

Chair: Brian Fortenbery, Electric Power Research Institute

Barriers and Opportunities for Lighting Controls
Jeremy Snyder (on behalf of Jennifer Brons), Rensselaer Polytechnic Institute Lighting Research Center

New Paradigms in Lighting Control & Energy Management
Joe Paradiso, Massachusetts Institute of Technology Media Laboratory

Outdoor Lighting Controls
Konstantinos Papamichael, U.C. Davis California Lighting Technology Center

No Wires, No Batteries, No Limits: How Innovative Lighting Controls are Energizing and Optimizing Buildings
Cory Vanderpool, EnOcean Alliance

Panel 2: Luminaires — 10:30–11:30

Materials and designs to improve the optical efficiency of luminaires for ambient, task, outdoor, and roadway lighting, which may consist of a body, ballasts, reflector, and lens.

Chair: Brian Fortenbery, Electric Power Research Institute

Lighting Technology Roadmap: Three Updates
Terry Clark, Finelite

Lighting Roadmapping Workshop
Eric Haugaard, CREE

Panel 3: General Lighting — 1:00–3:00

General approaches for minimizing energy use for building, roadway, and outdoor lighting promoting productivity, comfort, and health while maintaining affordability, longevity, and maintainability, including task/ambient lighting strategies and universal designs for people with limited abilities.

Chair: Michael Siminovitch, U.C. Davis California Lighting Technology Center

An Integrated Approach to Efficient Lighting
Jeremy Snyder (on behalf of Mariana Figueiro), Rensselaer Polytechnic Institute Lighting Research Center

Beyond LEDs: New Technology for Energy Efficient High Mast Lighting
Gregg Hollingsworth, Topanga Technologies

Plasma - Fitting Into the Mix
Gerald Rea, Stray Light Optical

Task / Ambient Lighting Application
Jerry Mix, Finelite

DC Power Distribution Systems for Next Generation Net Zero Energy Commercial Buildings
Brian Patterson, Emerge Alliance

Next Generation Opportunities for Deep Energy Savings: An Overview of California's Strategic Lighting Plan, The UC Davis Adaptive Lighting Initiative and Draft of California's LED Quality Standard
Michael Siminovitch, U.C. Davis California Lighting Technology Center

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LIGHTING PANEL PRESENTATIONS (CONTINUED)

Monday, September 24, 2012 | Cascade Ballroom, 2nd Floor

Panel 4: Daylighting — 3:15–5:15

Technologies and strategies used to bring useful daylight further into occupied spaces without compromising comfort.

Chair: Konstantinos Papamichael, U.C. Davis California Lighting Technology Center

Bringing People the Lighting They Want
Jeremy Snyder (on behalf of Mariana Figueiro), Rensselaer Polytechnic Institute Lighting Research Center

High Performance Daylighting Solutions – Tying High Quality Lighting Experience to the Most Cost Effective Energy Efficiency Measures
Grant Grable, Sunoptics

Integrated Building Simulation - Linking EnergyPlus and Radiance Using OpenStudio
Rob Guglielmetti, National Renewable Energy Laboratory

Overlit and Unproductive? It's Time to Harvest
Cory Vanderpool, EnOcean Alliance

Daylighting Harvesting Optimization
Konstantinos Papamichael, U.C. Davis California Lighting Technology Center

BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: RESIDENTIAL WHOLE BUILDING TRANSFORMATIONAL APPROACHES

Monday, September 24, 2012 | Broadway/Weidler/Halsey Room, 1st Floor

The corresponding roadmapping workshop is scheduled for Wednesday, September 26

Whole Building Transformational Approaches: Deep retrofits, which are a whole-building analysis and construction process that uses an integrative approach—rather than focusing on isolated energy systems—to achieve much larger energy savings than conventional energy retrofits. The Whole Building Transformational Approaches sessions are divided into 2 tracks: 1) Residential Buildings 2) Commercial Buildings.

Panel 1A: Retrofits to Residential Buildings — 1:00–3:00

Residential Buildings Track

Chair: Eric Werling, U.S. Department of Energy Building America

Pathways to Cost-Effective Retrofit Savings
Dave Roberts, National Renewable Energy Laboratory

Guidance for Achieving Deep Energy Savings in Homes
Iain Walker, Lawrence Berkeley National Laboratory

Does Any of this Stuff Actually Work?
Lew Harriman, Mason-Grant Consulting

Retrofits to Residential Buildings
Eric Werling, U.S. Department of Energy Building America

BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: RESIDENTIAL WHOLE BUILDING TRANSFORMATIONAL APPROACHES (CONTINUED)

Monday, September 24, 2012 | Broadway/Weidler/Halsey Room, 1st Floor

Panel 2A: Net Zero Energy Homes — 3:15–5:15

Residential Buildings Track

Chair: Ren Anderson, National Renewable Energy Laboratory

Utilities Role in Long Term ZNE Growth
Ram Narayanamurthy, Electric Power Research Institute

Zero Energy Homes: From Research Curiosity to Future Opportunity
Danny Parker, Florida Solar Energy Center

Zero Net Energy & Flat Load Profile Homes: Implications for Utilities
Rob Hammon, Consol, Inc.

Energy Market Opportunity: Zero Energy New Homes
Ren Anderson, National Renewable Energy Laboratory

BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: COMMERCIAL WHOLE BUILDING TRANSFORMATIONAL APPROACHES

Monday, September 24, 2012 | Sellwood / Ross Island / Morrison Room, 1st Floor

The corresponding roadmapping workshop is scheduled for Wednesday, September 26

Whole Building Transformational Approaches: Deep retrofits, which are a whole-building analysis and construction process that uses an integrative approach—rather than focusing on isolated energy systems—to achieve much larger energy savings than conventional energy retrofits. The Whole Building Transformational Approaches sessions are divided into 2 tracks: 1) Residential Buildings 2) Commercial Buildings.

Panel 1B: Deep Retrofits to Commercial Buildings — 1:00–3:00

Commercial Buildings Track

Chair: Sriram Somasundaram, Pacific Northwest National Laboratory

Defining "Deep" – Energy Performance Findings from 100 Retrofit Projects
Cathy Higgins, New Buildings Institute

Deep Energy Retrofits: Profitable processes for buildings and portfolios by
Victor Olgyay, Rocky Mountain Institute

Existing Building Renewal: R&D through Pilot Projects
John Jennings, Northwest Energy Efficiency Alliance

Overview of Advanced Energy Retrofit Guides (AERGs) Development
Sriram Somasundaram, Pacific Northwest National Laboratory

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BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: COMMERCIAL WHOLE BUILDING TRANSFORMATIONAL APPROACHES

(CONTINUED)

Monday, September 24, 2012 | Sellwood / Ross Island / Morrison Room, 1st Floor

Panel 2B: Net Zero Energy Commercial Buildings — 3:15–5:15

Commercial Buildings Track

Chair: Paul Torcellini, National Renewable Energy Laboratory

Net Zero Energy from the Practitioner's Perspective
Tom Hootman/ RNL

Getting to Zero: A First Look at the Costs and Features of Zero Energy Buildings
Heather Flint-Chatto, New Buildings Institute

Presentation title TBD
Ron Jarnagin

On the Pathway to Zero Energy Buildings, Definition, Potential, and Opportunities
Paul Torcellini, National Renewable Energy Laboratory

BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: BUILDING ENVELOPE AND BUILDING CONTROL SYSTEMS

Tuesday, September 25, 2012 | Cascade Ballroom, 2nd Floor

The corresponding roadmapping workshop is scheduled for Wednesday, September 26

Panel 1: Building Control Systems — 8:30–10:45

Chair: Ammi Amarnath, Electric Power Research Institute

Emerging Building Control Technologies
Eric Martinez, San Diego Gas & Electric

BACnet's Future Directions
Carl Neilson, Delta Controls

Intelligent Buildings for High Performance Building Operations
Paul Ehrlich, Building Intelligence Group

Advanced Buildings Control Using Wireless Sensors
Teja Kuruganti, Oak Ridge National Laboratory

Building Control Systems: Where Do We Go Next?
Ammi Amarnath, Electric Power Research Institute

BUILDING DESIGN / ENVELOPE PANEL PRESENTATIONS: WHOLE BUILDING ENVELOPE AND BUILDING CONTROL SYSTEMS (CONTINUED)

Tuesday, September 25, 2012 | Cascade Ballroom, 2nd Floor

Panel 2: Building Envelope—Windows — 11:00–12:00

Better glazing, frames, selective films and coatings, photochromic technology, skylights, better insulation and smart roofing. Presenters are divided into 3 panels: 1) Windows, 2)Smart Roofing, and 3)Insulation & Air Sealing for New Construction & Retrofits.

Chair: Charlie Curcija, Lawrence Berkeley National Laboratory

Presentation title TBD
James Larsen, Cardinal Glass

Panel 3: Building Envelope—Smart Roofing — 1:00–2:15

Chair: Walter Cuculic, SolarCity

Roofing Systems: DOE's Research Program to Reduce their Energy Impact
André Desjarlais, Oak Ridge National Laboratory

Presentation title TBD
Josh Plaisted, EchoFirst

Panel 4: Building Envelope—Insulation & Air Sealing for New Construction & Retrofits — 2:30–4:30

Chair: Mark Modera, U.C. Davis Western Cooling Efficiency Center

DOE's Research Program to Evaluate the Role Air Tightness Plays in the Energy Efficiency and Durability of Building Envelope Systems
André Desjarlais, Oak Ridge National Laboratory

Air Barriers: Do I Have One?
Tom Schneider/ Building Envelope Innovations, LLC

Air Leakage Control in New and Existing Buildings; Past Present and Future
Michael Lubliner, Washington State University

The Role of Air Sealing and Insulation in Achieving High Performance Homes
Sarah Widder, Pacific Northwest National Laboratory

Achieving and Certifying Building Envelope Air Tightness with an Aerosol-Based Automated Sealing Process
Mark Modera, U.C. Davis Western Cooling Efficiency Center

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ELECTRONICS PANEL PRESENTATIONS

Wednesday, September 26, 2012 | Sellwood / Ross Island / Morrison Room, 2nd Floor

The corresponding roadmapping workshop is scheduled for Thursday, September 27

Note: Most Electronics panel presentations will be held in the Sellwood / Ross Island / Morrison Room (2nd Floor), but **Panel 4B: System-level Efficiency** will be held in the Weidler / Halsey Room (2nd Floor).

Panel 1: External Controls & User Interfaces — 8:30–10:30

Controls such as smart power strips, occupancy sensors, and smart grid interfaces. User Interface considerations such as behavior modifications, use of power management capabilities, and data server virtualization.

Chair: Tomm Aldridge, Intel Corporation

Presentation title TBD
William Livingood, National Renewable Energy Laboratory

Presentation title TBD
Jim McMahon, Independent Consultant

Presentation title TBD
Ram Narayanamurthy, Electric Power Research Institute

Measured Savings: Smart Plug Strips and Timers
Laura Moorefield, Ecova

Panel 2: Component-level Efficiency — 10:45–12:00

More efficient end-use electronics, such as CPU efficiency and point of load converters.

Chair: Laura Moorefield, Ecova

Efficiency Beyond the Computer, Intel Labs Research into Sustainable Intelligent Living
Tomm Aldridge, Intel Corporation

Presentation title TBD
Brian Fortenbery, Electric Power Research Institute

Panel 3: Data Centers — 1:00–3:15

Chair: Dennis Symanski, Electric Power Research Institute

380V DC Power for Data Centers– An Engineering Perspective
Dave Geary, Universal Electric

Low Voltage Distribution in Data Centers – Opportunity for Improvement
B.J. Sonnenberg, Emerson Network Power

IT Efficiency Research Topics
Mark Monroe, Energetic Consulting

Energy Efficiency in Existing and New Data Centers – Where Opportunities May Lie
Mukesh Khattar, Oracle

Data Centers – What Can Be Done to Make Data Centers More Energy Efficient?
Dennis Symanski, Electric Power Research Institute

ELECTRONICS PANEL PRESENTATIONS (CONTINUED)

Wednesday, September 26, 2012 | Sellwood / Ross Island / Morrison Room, 2nd Floor

Panel 4A: Commercial & Residential Electronic Devices — 3:30–4:45

Commercial: Computers, printers, monitors, etc. Residential: Audio, home theaters, computers, set-top boxes, DVRs.

Chair: Bruce Nordman, Lawrence Berkeley National Laboratory

Set-Top Boxes and Small Network Equipment Market Drivers and Savings Opportunities
Gregg Hardy, Ecova

Presentation title TBD
Brian Fortenbery, Electric Power Research Institute

Electronics Technology Standards Needs
Bruce Nordman, Lawrence Berkeley National Laboratory

ELECTRONICS PANEL PRESENTATIONS (CONTINUED)

Wednesday, September 26, 2012 | Weidler / Halsey Room, 2nd Floor

Panel 4B: System-level Efficiency — 3:30–4:45

Approaches to electronics that work well together as well as power distribution options such as DC and higher-voltage systems.

Chair: Brian Patterson, Emerge Alliance

Climbing Peak Efficiency: Delivering Power and Control Simultaneously through DC Microgrids
Paul Savage, Nextek Power

DC Distribution In Buildings Including Homes, Commercial Buildings, Data Centers, and Telecom Central Offices
Dennis Symanski, Electric Power Research Institute

DC Power Distribution System Standards for Next Generation Net Zero Energy Commercial Buildings
Brian Patterson, Emerge Alliance

HVAC PANEL PRESENTATIONS

Wednesday, September 26, 2012 | Cascade Ballroom, 2nd Floor

The corresponding roadmapping workshop is scheduled for Thursday, September 27

Note: Most HVAC panel presentations will be held in the Cascade Ballroom (2nd Floor), but **Panel 3B: Modeling, Lab & Field Testing** will be held in the Weidler / Halsey Room (2nd Floor).

Panel 1: Fault Detection / Predictive Maintenance — 8:30–10:30

Automated notification of changes in components, such as dampers, amp draw, filters, etc., that will allow maintenance to be addressed sooner, thereby improving the system efficiency and minimize premature and major equipment failures

Chair: Srinivas Katipamula, Pacific Northwest National Laboratory

Fault Detection and Diagnostics for Rooftop Units: Standards are Key to Making it in the Market
Kristen Heinemeier, U.C. Davis California Lighting Technology Center

Retro-Commissioning in Buildings: Using Wireless Sensors for Improved Energy Efficiency
Teja Kuruganti, Oak Ridge National Laboratory

Energy Simulation Building Operations
Philip Haves, Lawrence Berkeley National Laboratory

Building Systems Diagnostics Work at Pacific Northwest National Laboratory
Srinivas Katipamula, Pacific Northwest National Laboratory

Panel 2: Heat Recovery and Use of Outside Air for Cooling and Ventilation — 10:45–12:00

Maximizing use of non-mechanical cooling with outside air, heat from cooled spaces to reduce energy use, natural ventilation, and demand-controlled ventilation.

Chair: Ram Narayanamurthy, Electric Power Research Institute

Economizer and Energy Recovery Improvements and New Regulations
Richard Lord, Carrier Corporation

Ventilation Retrofit Opportunities for Packaged HVAC
Reid Hart

Optimizing residential Energy Use with Ventilation Requirements
Ram Narayanamurthy, Electric Power Research Institute

Panel 3A: Motor-Driven Systems — 1:00–2:45

Energy efficient motors-driven systems in HVAC equipment, including fans, pumps, and compressors along with controls, particularly adjustable speed drives.

Chair: Marek Samotyj, Electric Power Research Institute

Current State and Direction of AC Motor Designs
Robert Hansen, ABB/Baldor/Reliance NW District Office

Integration of Motor-Driven Pump Systems to Improve Energy Efficiency
Greg Towsley, Grundfos

Saving Energy on HVAC Pumping Systems through Integrated Design
David Lee, Armstrong Pumps

HVAC PANEL PRESENTATIONS (CONTINUED)

Wednesday, September 26, 2012 | Cascade Ballroom, 2nd Floor

Panel 4: Inverter-driven Variable-Speed Compressor Systems 3:00–4:45

Variable speed compressors that provide much higher efficiencies and new refrigerant piping strategies, as used in Variable Refrigerant Flow systems and grocery store refrigeration.

Chair: Ron Domitrovic, Electric Power Research Institute

Variable Speed Air-Conditioning and Heat Pumps: Enhanced Energy Efficiency and Demand Response Capabilities
Robert Wilkins, Danfoss

Southern Company Research on Variable Refrigerant Flow Heat Pumps by
Pradeep Vitta, Southern Company

Presentation title TBD
Chris Bellshaw, Daikin AC (Americas), Inc.

HVAC PANEL PRESENTATIONS (CONTINUED)

Wednesday, September 26, 2012 | Weidler / Halsey Room, 2nd Floor

Panel 3B: Modeling, Lab & Field Testing 1:00–2:45

Using a combination of computer modeling software and lab or field testing to predict the performance of heating and cooling systems in a variety of applications.

Chair: Ron Domitrovic, Electric Power Research Institute

The Northwest Ductless Heat Pump Pilot Project Field Metering Results
Mark Johnson, Bonneville Power Administration

Enabling Whole Building Energy Modeling for Decision Makers
Nick Long, National Renewable Energy Laboratory

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National Energy Efficiency Technology Roadmapping Summit

September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

Roadmapping Workshop Primer

Technology Characteristics and R&D Programs
Residential & Commercial Roadmaps

What to expect today?

- Today's work is part of a national effort to revise a portfolio of energy efficiency technology roadmaps designed to:
  1. support the development of a shared, strategic research agenda;
  2. provide transparency regarding ongoing R&D efforts;
  3. limit redundant investment; and
  4. facilitate coordination and collaboration.
- Primary Focus: Revise Technology Characteristics and R&D Program content for Residential & Commercial Roadmaps
- Secondary Focus: Discuss proposed revisions to portfolio organizational structure
  – Revisions to be implemented for March 2013 draft of the *Roadmap Portfolio*
- Tertiary Focus: Prioritize a preselected subset of emerging technologies

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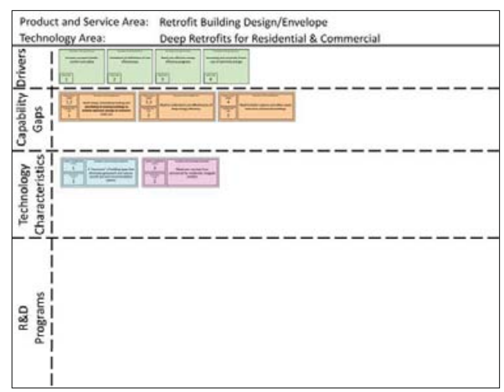
- These roadmaps are meant to be living documents, updated and revised as needed
- There are many ways to carry out this kind of process; today's effort reflects only one approach

Key roadmapping tasks

- For every roadmap "thread," subgroups will:
  – **Task 1**: Review existing Drivers and Capability Gaps (revised on Aug. 8)
  – **Task 2**: Review/confirm/revise Technology Characteristics
  – **Task 3**: Review/confirm/revise R&D Programs

Roadmap posters



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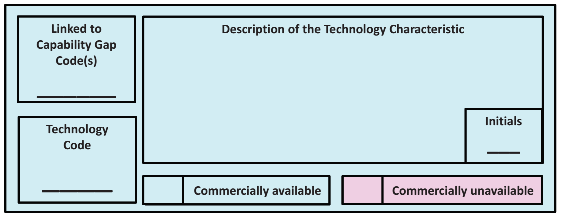
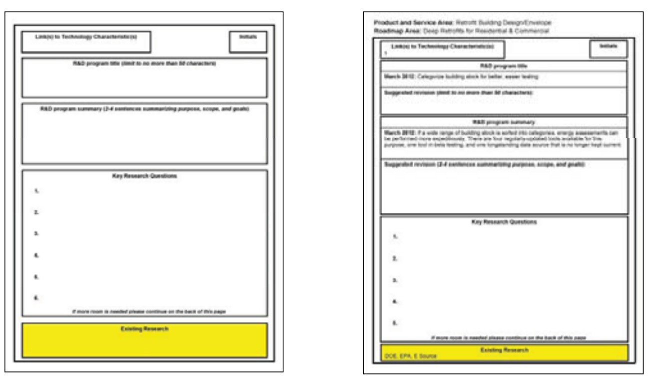
Technology Characteristic cards



R&D Program cards



Task 4: Subgroup Reporting

- Each subgroup will report efforts to the larger group
- All workshop participants will have an opportunity to ask questions and provide comments on the output of other subgroups
- Verbatim minutes will capture the discussion for use in post-workshop processing

Task 5: Presentation & Discussion on Proposed Revision to *Roadmap Portfolio* Organizational Structure

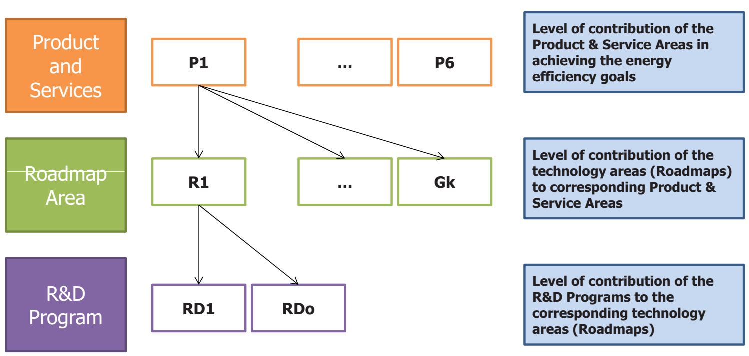
- Existing organizational structure is an artifact of first efforts out of the gate
  - It has been useful, to date, but we think there is a better way to keep things organized, moving forward
- Review handouts and discuss
- Discussion will be captured through verbatim minutes

What's next?

- Prioritization of R&D projects will be facilitated via webinar and online survey (post-Summit)
- Next official *Roadmap Portfolio* draft: March 2013
- Potential FY13 Roadmapping Workshops: Integrated Systems and Waste Heat Recovery
- FY13/FY14: If sufficient interest exists, begin piloting *Roadmap Portfolio* migration to the web (with password-protected wiki capability to enable real-time editing)

NATIONAL ENERGY EFFICIENCY TECHNOLOGY ROADMAPPING SUMMIT
September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

Prioritization Methodology



Highest possible score for R&D program would be 1000 (10x10x10)

NATIONAL ENERGY EFFICIENCY TECHNOLOGY ROADMAPPING SUMMIT
September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

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Appendix A10:

Sensors, Meters, & Energy Management Systems Workshop (Sep. 24, 2012)

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September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

SENSORS, METERS, ENERGY MANAGEMENT SYSTEMS ROADMAPPING WORKSHOP

Monday, September 24, 2012 | Adams / Jefferson Room, 1st Floor

Purpose

- Review/Confirm/Revise technology features and R&D programs for all residential and commercial roadmaps in the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio.*
- Prioritize (for deeper study) a sub-set of emerging technologies.

Facilitator: Joshua Binus (BPA)

Support: James V. Hillegas (BPA); Ibrahim Iskin (PSU ETM); Rob Penney (WSU EP); Ellen Petrill (EPRI); Jennifer Williamson (BPA); Jack Zeiger (WSU EP)

8:00 am	Summit Welcome, Opening Remarks, & Orientation (Cascade Ballroom)
9:00 am	**Welcome and Introductions**
9:30 am	**Orientation:** Background, Description of Goals/Process **Divide into Subgroups**
10:00 am	**Review / Confirm / Revise Technology Features and R&D Programs**
	For every roadmap "thread," each subgroup will execute the following: **Task 1:** Review existing Drivers and Capability Gaps (revised on Aug. 8) **Task 2:** Review/Confirm/Revise Technology Features **Task 3:** Review/Confirm/Revise R&D Programs
11:30 am	Keynote Presentations & Buffet Lunch (Cascade Ballroom)
1:00 pm	**Continue subgroup tasks**
3:30 pm	**Subgroup Reporting & Group Discussions** (captured via verbatim minutes)
4:30 pm	**Next Steps:** ▪ R&D Program Prioritization ▪ Revisions to *Roadmap Portfolio* Organization Structure ▪ *Roadmap Portfolio* March 2013 draft
5:00 pm	**Emerging Technologies Prioritization**
5:30 pm	**Adjourn**

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National EE Tech Roadmapping Summit

DoubleTree Hotel, Portland, Oregon ~ Sep. 24, 2012

Sensors, Meters, Energy Management Systems Roadmapping Workshop

Minutes of the sub-group reports &discussion of the *Roadmap Portfolio* organizational structure – REVISED 3:30–5:00 p.m.

Group A: Energy Management Services

1. Chad Corbin (Tendril)
2. Erin Erben (Eugene Water & Electric Board)
3. Marshall Hunt (Pacific Gas & Electric Company)
4. Eric Martinez (San Diego Gas & Electric)
5. Allie Robbins (Bonneville Power Administration)

Group B: Enterprise Energy and Maintenance Management Systems

6. Mike Bailey (Ecova)
7. Paul Ehrlich (Building Intelligence Group)
8. Mark Firestone (PAE Consulting Engineers)
9. Hanna Kramer (Portland Energy Conservation, Inc.)
10. Bill Livingood (National Renewable Energy Laboratory)
11. Carl Neilson (Delta Controls)
12. Alecia Ward (Weidt Group)

Group C: Real-Time Smart Electric Power Measurement of Facilities

13. Bruce Baccei (Sacramento Municipal Utility District)
14. Hampden Kuhns (LoadIQ LLC)
15. Irfan Rehmanji (BC Hydro)
16. Nate Taylor (San Diego Gas & Electric)

Group D: Low-Cost Savings Verification Techniques

17. Jack Callahan (Bonneville Power Administration)
18. Terry Egnor (MicroGrid Inc.)
19. Suzanne Frew (Snohomish County PUD)
20. Bryan Hulsizer (Optimal Energy)
21. Paul Mathew (Lawrence Berkeley National Laboratory)
22. Harvey Sachs (American Council for an Energy-Efficient Economy)
23. Brinda Thomas (Carnegie Mellon University)
24. Phoebe Carner Warren (Seattle City Light)

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Group E: Smart Device-Level Controls Responsive to User and Environment; Easy/Simple User Interface Controls

25. Abdullah Ahmed (Sempra Utilities)
26. Brad Acker (University of Idaho Integrated Design Laboratory)
27. Doug Avery (Southern California Edison)
28. Lieko Earle (National Renewable Energy Laboratory)
29. Jeff Harris (Northwest Energy Efficiency Alliance)
30. Dick Lord (Carrier Corp.)
31. Jim McMahon (Better Climate)
32. Igor Mezic (University of California Santa Barbara)
33. Ram Narayanmurthy (Electric Power Research Institute)
34. Jay Stein (E Source)

Other participants (sub-groups not identified):

35. Lew Harriman (Mason-Grant Consulting)
36. David Kenney (Oregon Built Environment & Sustainability Center)
37. Pete Pengilly (Idaho Power Company)

Minutes by James V. Hillegas (Bonneville Power Administration)

Group B: Enterprise Energy and Maintenance Management Systems

Neilson: We started off by questioning the definition of the roadmap that we're working on and revised it slightly. We ended up with the title "Enterprise Energy Management," and what this means is that it involves energy management to scale—"enterprise" means a campus, but there are other ways to scale as well.

We worked a lot on the technology characteristics, but I'm going to focus on a few of the research projects that we've proposed. One of these was taking data and making it useful in a way that leads to action. This is a theme that resonates across a lot of these projects. One of these is to have good data presentation methods—what kinds of ways do people look at data so that they can take action? There was an actual research proposal on this a while back, but I'm not sure if it got funded.

Our next project is one that came into two groups. The first was testing and determining what kinds of data is it that gets turned into information, and what are the results. Utilities and owners of big buildings want to know what happens if the energy management system is installed and if there are savings to be expected from different applications. There's a use case to be made because you don't just install a tool and automatically get savings, so we need different use cases involving such things as behavior-based programs and strategic energy management programs. What kinds of savings can we achieve from these systems? Predicted and actual savings are all over the place. Everyone says up to thirty percent but we don't know.

The other area we worked on was around overcoming the siloed approach to tools and, using the twenty year vision, take these tools to help you save energy by identifying measures, identifying demand response possibilities, using automatic system optimization, and applying other approaches that do things in an integrated way to get away from siloed systems that don't talk to one another. Our twenty year vision is having these integrated tools. We need integration prototypes to be tested and validated to see how accurate these tools really are. They need to be validated to see if the savings are true.

Something Mike [Bailey] added to the goal of integrating these systems was looking at different market segments—different segments have different effects on the models. We need market segmentation to determine the appropriate approaches.

Livingood: The next few areas that we worked on that I'll discuss are our "science-fiction" ones, where we have tried to see twenty years out. First here is the "beige button" idea, which is similar to the "Green Button" (http://www.greenbuttondata.org/) and "white button" approaches. This is taking steps forward and includes having ready access to architectural design, and metering, and the new equipment that's been placed in a building, and having that information all readily available to users.

Another is point mapping. Point mapping is very tedious and error-prone. We need some mechanism to automate this—assigning a variable name and a description automatically. There is some work going on at American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) to create a framework, but there is support needed to complement the ASHRAE effort.[1] Another aspect of this is automated quality assurance (QA) and quality control (QC) of meters. We're already collecting much data on this but often we don't believe it because the meters aren't calibrated to the actual equipment. Perhaps build QA and QC into the standard process?

Another item is the development of standard communications protocols. This is underway but there are key aspects that are not being addressed as they should.

Connected as well to the point mapping item: if manufacturers could provide this automatically, then the commercial aggregation systems could such this information up automatically. ASHRAE is taking this on as well but also needs support.

We have a few items that are related to having standardized models to collect the data and also to determine what data to collect and what to do with the data.

A couple of others to mention. We need to develop algorithms for this information, and another is connected to the need for security for this data. One key point to make for this is that we're not suggesting that Bonneville Power Administration try to take on this security thing by itself, because there are many companies doing this already, but the question is, what security efforts are underway that building managers must be aware of or can leverage to their advantage?

Acker: This really doesn't pertain directly to what has just been presented, but the category of energy management systems is so huge and involves so many topics, it seems like there are other topics that could be broken-out and various threads that could be pursued. The spreadsheet we sent out had three or four items that related to energy management systems, but it's a huge ball.

Binus: We'll be talking about this very issue a bit later this afternoon when we discuss the re-organization of the *Roadmap Portfolio*.

Ehrlich: When we define this, it's not the same as the definition already in the Portfolio. We're defining the business system perspective on this at the enterprise level, not the building level. There are a whole series of things that have to do with optimization and control, but we didn't address that.

Livingood: We recognized that in our August session. Maybe we could break this up in terms of challenges, not just using the current categories?

Callahan: Our work on the Low-Cost Savings Verification Techniques roadmap did overlap with the work that you all have done here.

Group C: Real-Time Smart Electric Power Measurement of Facilities

Kuhns: We started before lunch kind of confused on the process, so we started with discussing the importance of doing a literature review of what kind of systems are already out there, and asking for a central database out there that

[1] See, for example, William Livingood, Justin Stein, Toby Considine, and Chuck Sloup, "Review of Current Data Exchange Practices: Providing Descriptive Data to Assist with Building Operations Decisions," National Renewable Energy Laboratory Technical Report NREL/TP-5500-50073, May 2011, http://www.nrel.gov/docs/fy11osti/50073.pdf

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includes equipment that we could use. We determined that this was one of our key needs, to build such a database. So this really needs to be a long-term effort because the area changes so quickly. What's also important is to make sure that this database is publically available so that anyone can use it an act on it.

The two other research topics that we talked about are related to standards. The other two have applications to hardware design, and, ultimately, to a tool to benefit the end user.

The second topic that we had was what kind of information to keep regarding time of use and other measurements. If you're a small business, the weather report from the airport might be sufficient, but if you're a large facility there might be a need for a weather station on the roof, so our item here pertained to the question: What kind of system to you need?

The third area was that there was not a standard regarding how this data is to be collected and used, what the sampling rates and the precision of sampling should be for different applications, and how precise is precise enough. Depending upon the application, our questions were related to how precise and how important is this information for managing different-sized facilities.

Rehmanji: That was more on the standards side of things. I'm going to speak now on the work that our group did on the hardware side.

Speaking of overlap, Hampden mentioned how fault detection and diagnostics (FDD) can be integrated. There are really a broad range of products, generally on the software side, that define themselves as fault detection (FD) systems, but there are not real evaluation tools available to the customers to understand these. There's a broad range of products and sophistication levels out there, band I think there's room to provide value to our customers on these products.

Market development and screening of gateway factors is another area we discussed. You have smart meters deployed, but the information is only going back to the utility, and maybe the bandwidth of the system is only able to send every fifteen minutes or so. Is there a way to send the data more frequently so that the customer can leverage data more directly?

The last item is somewhat generic and is about installable sensors for commercial buildings. How can we collectively make sensors inexpensive and easy to install, rather than having a high-cost proposal put together? We all know that metering and sensors are a good thing, but how do we make them more cost effective?

Ehrlich: I see a couple of challenges. One is, are you thinking about metering below the building level? Particularly metering of key areas such as plug loads, HVAC systems, and lighting loads?

Rehmanji: Yes we did. We added in the Technology Characteristics swim lane a couple of things that involve plug load metering and sub-building metering.

Ehrlich: Something to keep in mind from the Energy Management System report-out is that other systems, such as water, steam, and others, are all important.

Rehmanji: I think it all relates back to making sensors less expensive.

Ehrlich: Yes, but it's already being metered.

Rehmanji: At the meter level.

Kuhns: We also changed on of our Capability Gaps to reflect other sources of energy besides electricity.

Sachs: Did you talk at all about the analytics that you could run on that data?

Kuhns: That's the FD.

Rehmanji: We separated that out because we thought it would be covered under different roadmaps in this product and service area.

Group A: Energy Management Services

Erben: We had the Energy Management Services area and my view of our work is that it probably bent toward residential and small commercial sectors. We added Capability Gaps around self-learning systems and optimization. Our research and development programs included both simple and complex ideas.

First, we have one on residential energy disaggregation. Probably there's already research happening in this area, but there's more to be done in this area. The one research and development program that we inherited was to make use of money already spent to ensure that there's a good application of funds.

Here we have value engineering. Cost effectiveness came up over and over again. What can we change at the sensor level to make it all more cost effective?

Hunt: Self-learning became a very important part of the work that we did because it can integrate with all of the others. One of the key things about the commercial and residential sectors is that we need to have an accordion so that people have the choice to go deeper. We need to allow users to optimize building operations with little or no expertise. The controls must get smarter for residential, office, and small commercial buildings.

We developed six research and development program cards with key questions in each one to generate different areas for research for people to integrate into a request for proposal. The first one pertains to displays; the second is what type of sensors are needed—which is covered in other roadmaps as well. This is especially important when considering the improvements that a tenant has made that will then be removed once the lease is up.

Another area concerns what analytic protocols are needed to make this work—to integrate data and learning such as FD, trending, learning, interaction of system faults, etc. What level of automation is needed now and in the future? We've got all this smart learning going on and two-way communications systems, so how do we make this happen? We'll be amazed at what houses and small commercial buildings need in twenty years.

The sixth one is, how is optimization achieved? This means different things to different people and is also different for given applications.

We also need a smart notification mechanism, something like a "check engine" light—something simple to view and interpret.

Erben: I'll add that one key thing for us with the car analogy was that we all know that there is data overload, so our "check engine" light should be focused on just sending actionable information to the customer, not to overload them. Only have them check the oil when they need to care.

Kuhns: These looked like technology and software as a service, is there also room for something around energy service business models for small commercial customers? Getting them to pay any attention to this is hard, are there any ideas around providing this service, such as with aggregators?

Hunt: That's a good point.

Mathew: The U.S. Department of Energy is just about to start a project on that, on small building Energy Management Standards (EnMS).[2]

Egnor: This is not a question, but a comment: You might want to add the New Building Institute to your research and development card you created for the simple version, because they have a new product called FirstView that fits into that category.[3]

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[2] See Paul Scheihing, "Energy Management Standards (EnMS)," U.S. Department of Energy, Jan. 2009, https://www1.eere.energy.gov/manufacturing/pdfs/webcast_2009-0122_energy_mngmnt_stnds.pdf.
[3] See http://www.newbuildings.org/firstview.

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Ehrlich: This is really a fascinating area. I started researching this in 2001. It feels to me like just in the last year something has suddenly started to happen. Both utilities and customers were interested in this but not paying for it, but just in the past year we have seen the Nest web-enabled thermostat product, and then cable companies are also now getting interested. I'm finally starting to see advertising for these kinds of things.

Hunt: At PG&E we are also very interested in customer satisfaction and safety. This has really picked up. We're kind of klutzy right now, I think. A lot of folks want to be left alone and could do so with this kind of system.

Group D: Low-Cost Savings Verification Techniques

Callahan: The first thing we did was look at the drivers and capability gaps. They were fairly general and worked OK, but we added a couple of specific items. One driver we added was about increasing development and availability of analytics. We thought that the availability of low-cost sensors and data storage systems is a big driver. Another driver we added involved the demand by utilities and owners for energy savings to increase interest in behavior-based systems. In summary, there's a continuing demand for very high quality verification.

That's what we looked at first. We also added in several capability gaps. Our research and development programs one that came up in several roadmaps: We need to have good data, so we included a program for low-cost embedded energy use sensors and verification of finely-disaggregated data. Energy—not just electricity—metered by embedded sensors installed by the original equipment manufacturers, with the data somehow being communicated back through the use of standard protocols and communications systems. Are key research questions here involved how we can develop sensors with the integrated communications systems. How does this integrate with existing building controls and sensors? You've got a separate system for energy use and for controls, so how do they integrate? Another key question was, how do you integrate with other kinds of sensors?

Thomas: We also thought that we needed some comparison of low-cost building metering coupled with some kind of international protocol compliance devices, especially for end-use data disaggregation. Some of this was talked about in other presentations.

Egnor: Somewhat related to this is developing regression that allows for total building energy use analysis and disaggregated end-use. What kind of accuracy could be achieved in this system? Inverse modeling says that you take the data that the building has used over the year and from it you infer—you work the data back to what you got, rather than working with the building components and trying to work forward. The advantage is that you can work with as little as a year of utility data and get to the answers more quickly. What level of accuracy can be achieved from this methodology? Also, if you're metering a building over time, if it's long enough it's almost guaranteed that you'll have significant changes in building occupancy and structure. You have to be able to identify energy savings from installed measures, and find out how to remove the other changes from the calculus so that energy efficiency isn't counted as losing tenants. Can the methods achieve the cost reductions necessary?

Mathew: Harvey Sachs suggested this one: "Characterizing buildings for energy analysis."[4] Inverse calculation is much more useful when you have the metadata along with the end-use data. There is a need for standardization and characterization—even the measurement like square footage isn't always standardized. He was suggesting research around this. What information could I gather? How much to categorize buildings around building systems to build a common taxonomy?

Warren: In Seattle we're in the ozone already, we're already like California in that we're in a situation where we need to require meters at lower scales so that we can get this data. We're also seeing many companies putting the data in the cloud and applying automated analysis to make use of the data. Many facilities are applying this as well. We need to get accountability for these building systems. One thing really exciting is the huge interest we're seeing among control companies to get energy savings information from embedded systems. This is not entirely in the public sector. If there isn't some public funding going to develop transparent systems and protocols, this is not a good thing. My recommendation is to put public funding out there to get transparency regarding analytics and algorithms. Id' recommend that there be simple enough systems out there that allow users, managers, and utilities to be able to see this stuff clearly. Automated measurements of savings provided with clear indices.

[4] Harvey Sachs' post-Summit comment: "OK with me."

Earle: I just wanted to add to the one you mentioned about the need for data standardization, the National Renewable Energy Laboratory's Building America Field Data Repository (BAFDR).[5] This currently holds about 1,500 residential buildings, and is capable of recording building characteristics and utility bill data as well as field monitoring information. It's intended to be a central repository of data on residential building characteristics and energy use to be used by researchers to compare simulation predictions with actual energy use.

Mathew: Good point. DOE has a related effort, and we are trying to figure out a standard taxonomy for both commercial and residential buildings.

Another item we discussed was related to "acceptable" measurement and verification (M&V). How much is acceptable for your business case? The ideal is to get a framework for making those decisions, considering as well the uncertainty that comes out of different protocols and tailoring your M&V in accordance with the time and expense involved based upon the actual business case and let that drive M&V.

Acker: On that last one maybe specify surrogates, such as that you may be measuring other systems such as run time, revolutions per minute, frequency, etc. Did that come up on other projects? Rather than measuring the primary variable, might it be possible to measure an easier and cheaper variable with the same kind of accuracy?

Callahan: We did not discuss that directly. We didn't write this one up, but I've thought about combining the lab work and the field work. Can you study the dependent variable in the lab, and in the field study the independent variable? I'll write another card for this one.

Mezic: What struck me as interesting was the statement "back when simulation was the answer." What I'm not hearing is how to still use the simulation. Seems like the pendulum has swung the other way, that simulations can't get you there. I happen to think otherwise. This is a complex system, but I wonder if there's a research question there?

Warren: We talked about creating a standard system to get at this information, such as speed is a good proxy for kW on a motor.

Mathew: You make a good point, but I think where we're coming from, one of the key drivers is increasing demand from utilities and others who are skeptical about energy savings claims coming from models. What we're trying to get at is the need for savings verification methods that have connections to real data.

Mezic: Skepticism is a good thing. We all know the data. But for me the data needs to be used to enhance the model calibration. The reason why weather prediction is way better now than it was twenty years ago is because they've been looping the real-world data back into the models.

Egnor: The issue here is looking at scaling and cost. The function is the driver. If you're looking at accuracy, then looping is the way to go, but if you're looking for smaller applications, then you're not going to be looking at any looping. It also depends on the function of utility billing, or if they're being evaluated for energy savings, or whether the purpose is simply to give information to the building owner or occupants at an actionable level, then you're looking at simplified systems.

Binus: There's more to say here but we're pressed for time, so feel free to add your additional comments to the minutes once we've sent them out to you all.

Ward: I just wanted to say a final thing, that there's a good deal of interplay between the roadmap that was just covered and the one that my group worked on. We had a lot of discussion about this. One of the things that we should challenge ourselves with is doing research around high-fidelity, low-cost solutions.

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[5] See National Renewable Energy Laboratory Building Technologies Program, "Building America Technical Highlight: NREL's Field Data Repository Supports Accurate Home Energy Analysis," Feb. 2012, http://www.nrel.gov/docs/fy12osti/54026.pdf.

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Group E: Smart Device-Level Controls Responsive to User and Environment; Easy/Simple User Interface Controls

Lord: The first thing we did in working with the Easy/Simple User Interface Controls roadmap was ignore the instructions and add more and different drivers and several capability gaps.

The key technology characteristics we included were user-friendly systems, an item that was triggered by the non-user-friendliness of some systems. We talked a lot about what kinds of devices these will reside on, such as personal computers or iPads or something that resides on the thermostat. We also recognize that a lot becomes very differentiated between residential, commercial, and industrial users, so we tried to address that as well.

Another key technology characteristic was interoperability. Key themes in our group were user friendliness tailored for different devices, among others.

Regarding actual research and development program questions, a lot of our work was more focused on software and user-end research, as opposed to technologies. For example, what kind of information do users want, besides what kind of information is already out there. The percept ion of comfort, there's a whole variety of things beyond temperature that influence comfort, so we need to understand better these other factors, such as humidity.

One other was what kind of savings come from energy management systems, so we asked questions about what was preventing people from using these systems effectively today.

Another topic we addressed had to do with the fact that as systems become smarter, with the addition of learning algorithms, to what extent does that conflict with user controls, and can the user override these controls? Is this appropriate, and if so, how do we default back to the smart system?

Another area had to do with human factors and understanding when users need the information—is it by way of a standalone app, or something else? One example is how about on a calendar, I can just schedule a meeting in the evening, meaning I won't be at home, and the calendar app asks me if I will need the heat on at home or not. At the industrial level, rather than having separate energy management systems, there is a comprehensive energy management system with the enterprise system. Thinking more holistically about how energy use and management can be integrated.

This got us thinking about interoperability, such as using Microsoft Outlook. What kinds of formats are needed, what kinds of interfaces are needed?

Demand response (DR) was another area we looked at. How do you actually program a device for DR? There's some industrial programs that have this built in, but for commercial and residential applications, what kinds of interfaces do we need, what kinds of information is needed to make this work?

Kuhns: A general question for you: What's in the domain of research and development as opposed to what companies should be doing to figure out what customers need? I know some things need research to move along, but for user interfaces it seems tricky.

Lord: Good question. There are some companies doing the fundamental research and development, but then there's also opportunities for companies to work with national labs to learn about what users need. Intel does this to some degree by having their researchers live in other cultures for months at a time to understand different user needs.

Thomas: What about research on default settings or schedules that users could just go back to?

Lord: We capture a little bit of that by wondering that if people aren't using the default settings, why not? Also, is there more learning that users can provide at the front-end as well as use over time?

Corbin: Did you consider location-based awareness to simplify things?

Lord: You mean if I'm in Washington D.C. does my house in Portland need heating? No, we didn't address that one.

Stein: We got really excited about our subject, Smart Device-Level Controls Responsive to User and Environment. What got us jazzed is that we saw this area as really key for totally integrating building controls. If you're going to take advantage of really controlling the building, you need to collect data from a wide array of sensors and systems, such as occupancy sensors, lighting and heating sensors, etc., to optimize performance that way. We talked about this and kind of got stuck. We despaired at the barriers to do this kind of thing. Sure, this would be cool to do, and there's already a ton of sensors on the market, but they're not working together. Why not?

There are two big issues here. One is a lack of open protocols for all these systems and sensors to talk to one another. Number two is the need for some kind of motivation for all of these original equipment manufacturers to adopt open protocols that we envision are necessary to provide fully integrated and comprehensive building energy management systems. We kept coming back to the issue that it would take some kind of performance specifications to motivate people and the disparate parties to get them working together on something they've been avoiding doing for decades. We need some kind of performance specification based on measured data to compel these changes. To account for that, we added a driver having to do with utility energy efficiency programs. We wrote up a whole research and development card based on the research agenda that it would take to explore these topics.

Another area we talked about that might get to the same result is the area of web-enabled programmable thermostats. We expanded our thinking about it today. How much cheaper Internet-connected systems are than traditional building automation systems? They are cheaper by a factor of five. They don't do as much, but they are so much less expensive. We talked a lot about expanding Internet-based control beyond web-enabled thermostats, using wireless routers and such to create plug-n-play systems that could all talk to each other, and we wondered if it could be done way cheaper than conventional building automation systems.

We talked about other things as well, but those are the biggest items. Team, did I miss something?

Earle: Maybe provide a high-level overview of the others?

Stein: We spent a lot of time on the existing ones that we fleshed-out, including web-enabled thermostats; incorporating cell phones so that operators and occupants could use them; the use of power-line carriers as a way of cheaply integrating sensors and input/output devices without installing new wires.

Warren: I'm a little confused in what you're presenting. A couple of questions might help clarify things. I know you have a broad area that you've covered. When you talk about people adopting open protocols, I wonder if you're talking about residential, commercial, and/or the industrial sector?

Stein: Yes. Our experience is that the existing open protocols are not getting the job done. BACnet-based systems are really not cheap enough to find their way into many buildings.[6]

Warren: Our experience is that BACnet-based systems cost as much as direct digital control (DDC) systems. Are you comparing web-enabled systems with BACnet?

Stein: Yes. One-fifth the price includes the web-enabled systems and infrastructure. For big buildings this barrier is not so much an issue regarding the BACnet system.

Warren: The reason I ask is that you wouldn't be using [unable to record complete statement].

Stein: Web-enabled systems are not very common, but they have the potential of replacing the current systems. Like any disruptive technology, web-enabled systems are being dismissed by the market leaders.

Earle: The cost issue was big for many on the team, but it wasn't the only issue we looked at. We kept coming back to the need to better understand what kinds of information can be collected in the building and how that information can be used to manage energy use more effectively, and before we get to the widgets we need to know this. For smart appliances and other building systems that might be capable of taking a signal from the utility, what else can they offer the user beyond load shedding? What is the analysis needed to understand this better?

[6] Data Communication Protocol for Building Automation and Control Networks. See http://www.bacnet.org/.

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Mezic: An additional comment here. Have you seen a thermo engineering book that actually talks about the interaction effects, rather than an HVAC text focused on a single room? I've seen a book like this in Germany, but when I'm teaching my students here in the States I can't pick up a book that shows the interaction effects. A proper research topic would be to write this book.

Roadmap Portfolio re-organization discussion

Bailey: One item that would be helpful would be to differentiate between residential, commercial, and industrial. This is how utilities look at it. They are very different areas with different needs requiring different approaches. Some of the gaps, issues, and solutions here are appropriate for residential, but not for commercial, and vice-versa.

Binus: Is it the attitude of the room that we have differentiated the sector for each of the headers here? Within each thread and within the portfolio as a whole?

Bailey: For example, looking at Building Design/Envelope, most of these are residential, but maybe only insulation applies to the commercial sector.

Binus: So, within this product and service area, would it be better if we divide up the threads by sector rather than by functionality, and have the roadmap threads under each of these categories?

Egnor: The issue is that we've had this artificial line for many years now, so long that we think it's real. The reality is that small commercial is a lot like residential and medium commercial is different from large-scale commercial. We need to think more about scale and applicability. For example, high-rise apartment buildings would be similar to commercial sector buildings and have similar needs to a large office building.

Ehrlich: I'd also come back to your comment this morning regarding systems. Don't lose that idea. I'm looking at these roadmaps and these form the basis of building systems. What is your time frame—two years, five years, ten years?

Binus: That's a good question. Aspirationally, our time frame is the twenty-year horizon, but functionally most of the stuff that we've included thus far is in the five-to-ten year horizon. Getting people to thin out to the next twenty years is difficult.

Ehrlich: The challenge we have as an industry is that beyond five years we begin to fall off a cliff. The systems we need to get to that level are dramatically different. If you want to get to that, then there's a different research agenda involved. Most everything we talk about involves making nice improvements to what we're doing today. If you want to start doing passive building designs and integrated systems, then it's much different than what you have here. Incremental change versus revolutionary change—if you really want 85 percent of your region's load growth to be met by energy efficiency, you'll need something different.

Binus: We may have to implement a different structure for our portfolio. If we provide the systems integration roadmaps, that may change our structure.

Kramer: You may find that the overlap of things pops out. I think that differentiating the residential and commercial sectors is important and we have to go there. Perhaps there are four categories to consider in this product and service area: sensors, meters, and devices is one; software tools is another; business models is another; and protocols is another, and it's woven into all of the other three.

Binus: Does anyone have any comments on this idea? No matter how we reorganize this, not everyone will like it, but we're going to make the most informed decision that we can make.

Callahan: Another category could include analytical techniques. This is similar to tools, but it's different—we need better algorithms, but this is not necessarily a "tool."

Egnor: Your comment about integration is a critical one to help people think about where the research is going. Where we were in the automotive industry serves as an example here: when we were thinking about using computers to improve engine performance, and then extending this into using computers to help in braking, that's kind of where we are with building systems. Lighting controls are beginning to be smart enough to do HVAC as well. It has nothing to do with smarts, it has to do with integration versus silos and turf wars. We are right at the tipping point now where we have the right smarts at the level of sub-systems, and there's nothing running the show anymore. The Java Application Control Engine (JACE) systems are an example of this kind of integration, and use of these systems is going to be driven just as computers in cars were driven—not entirely by the companies but also by outside forces wanting stuff that is safer, environmentally friendly, comfortable, etc.[7] We need to be thinking about this whole move away from all of these compartments. I would suggest a way of thinking less about tracking things like a swim lane and more like linking things through a matrix, with some ways point forward that are "hot."

Livingood: In August we also had thoughts about changing these to reflect the challenges that we are facing. In the lighting product and service area it makes sense for the categories that are used in the current organizational structure, but in the energy management systems category, we've come up with a lot of similar themes, such as interoperability, and we should be thinking about those. I would broaden Hannah's categories a bit to include accuracy of data, or ensuring that we're collecting what we want to collect, and I think this is important to include. Hannah's are a great start, maybe we include those with some tweaks to it.

Hulsizer: We all realize that there are issues that transcend these vertical applications, and tracking this is necessary. I heard four or five of these questions raised that I know are addressed by emerging programs, and we didn't talk about keeping track of emerging programs that are coming around, by the Department of Energy, International Organization for Standardization, etc., and if we don't do anything to make them work together, we'll lose out.

Ehrlich: This would also include working with Energy Efficient Buildings Hub for the near-term research and development, and Advanced Research Projects Agency-Energy (ARPA-E) for the longer-term stuff.[8]

McMahon: Reorganization may occur along the time horizon. I don't think that you need five sectors for everything. Maybe you label which sector is primarily responsible for the area. Also, the time horizon depends on what you want to look at. With information technologies, ten years might not make sense because of the significant changes being made every six months, but with HVAC it would make sense to look at game-changing technologies.

Egnor: I just can't resist paraphrasing Henry Ford here: when asked about designing cars, he said that if he would have asked the common public to help in the design, they would have asked for faster horses.

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[7] See http://www.tridium.com/cs/products_/_services/jace.

[8] For the Energy Efficient Buildings Hub see http://www.eebhub.org/. For the Advanced Research Projects Agency-Energy see http://arpa-e.energy.gov/.

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Appendix A11:
Lighting Workshop (Sep. 25, 2012)

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September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

LIGHTING ROADMAPPING WORKSHOP

Tuesday, September 25, 2012 | Adams / Jefferson Room, 1st Floor

Purpose

- Review/Confirm/Revise technology features and R&D programs for all residential and commercial roadmaps in the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio.*
- Prioritize (for deeper study) a sub-set of emerging technologies.

Facilitator: Joshua Binus (BPA)

Support: James V. Hillegas (BPA); Ibrahim Iskin (PSU ETM); Rob Penney (WSU EP); Ellen Petrill (EPRI); Jennifer Williamson (BPA); Jack Zeiger (WSU EP)

8:00 am	Summit Welcome and Orientation (Cascade Ballroom)
8:30 am	**Welcome and Introductions**
9:00 am	**Orientation:** Background, Description of Goals/Process **Divide into Subgroups**
9:30 am	**Review / Confirm / Revise Technology Features and R&D Programs**
	For every roadmap "thread," each subgroup will execute the following: **Task 1:** Review existing Drivers and Capability Gaps (revised on Aug. 8) **Task 2:** Review/Confirm/Revise Technology Features **Task 3:** Review/Confirm/Revise R&D Programs
11:30 am	Plated Lunch (delivered to room)
12:15 pm	**Continue subgroup tasks**
2:45 pm	**Subgroup Reporting & Group Discussions** (captured via verbatim minutes)
3:45 pm	**Next Steps:** ▪ R&D Program Prioritization ▪ Revisions to *Roadmap Portfolio* Organization Structure ▪ *Roadmap Portfolio* March 2013 draft
4:15 pm	**Emerging Technologies Prioritization**
5:00 pm	**Adjourn**

BONNEVILLE POWER ADMINISTRATION | EPRI ELECTRIC POWER RESEARCH INSTITUTE | neea | WASHINGTON STATE UNIVERSITY EXTENSION ENERGY PROGRAM | Portland State UNIVERSITY ETM

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National EE Tech Roadmapping Summit

DoubleTree Hotel, Portland, Oregon ~ Sep. 25, 2012

Lighting Roadmapping Workshop

Minutes of the sub-group reports & discussion of the *Roadmap Portfolio* organizational structure – REVISED 2:45-4:15 p.m.

Group A: General Lighting

1. Craig Ciranny (Bonneville Power Administration)
2. Charlie Grist (Northwest Power and Conservation Council)
3. Gregg Hollingsworth (Topanga)
4. Laura Moorefield (Ecova)
5. Kurt Nielson (Light Doctor)
6. Brian Patterson (Armstrong World Industries)
7. Gerald Rea (Stray Light Optical)
8. Jeremy Snyder (Rensselaer Polytechnic Institute Lighting Research Center)

Group B: Solid State Lighting

9. Marc Ledbetter (Pacific Northwest National Laboratory)
10. Jon Linn (Northeast Energy Efficiency Partnerships)
11. Levin Nock (Bonneville Power Administration)
12. Graham Parker (Pacific Northwest National Laboratory)
13. Martin Shelley (Idaho Power Company)
14. Joe Vaccher (Eugene Water & Electric Board)
15. Carolyn Weiner (Pacific Gas & Electric)
16. Jerry Wright (Seattle City Light)

Group C: Lighting Controls + Daylighting

17. Doug Avery (Southern California Edison)
18. Brian Fortenbery (Electric Power Research Institute)
19. Grant Grable (SunOptics)
20. Robert Guglielmetti (National Renewable Energy Laboratory)
21. Michael Lane (Puget Sound Energy)
22. Kosta Papamichael (University of California Davis)
23. Joeseph A. Paradiso (Massachusetts Institute of Technology)
24. Michael Poplawski (Pacific Northwest National Laboratory)
25. Mark Rehley (Northwest Energy Efficiency Alliance)
26. Irfan Rehmanji (BC Hydro)
27. Paul Savage (Nextek Power Systems)
28. Dave Thompson (Avista Corporation)
29. Cory Vanderpool (EnOcean Alliance)

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Group D: Task/Ambient Lighting; Luminaires

30. Terry Clark (Finelite)
31. Karl Johnson (California Institute for Energy and Environment at UC Davis)
32. Tom Reddoch (Electric Power Research Institute)
33. Michael Siminovitch (University of California Davis)
34. Eric Strandberg (Lighting Design Lab)
35. Mark Whitney (Portland General Electric)

Minutes by James V. Hillegas (Bonneville Power Administration)

Group B: Solid State Lighting

Ledbetter: We ended up developing an R&D program that we called "SSL Luminaires" in addition to lighting. The luminaires is a platform for doing other things than lighting. Are there additional functions that we haven't thought of yet that can be included to improve the functionality, such as broadband communications within opaque walls in a room to replace current wireless systems? WE also had one of the presenters yesterday talk about tunable systems that are better at adjusting moods and increasing functionality. Research questions included can added functions be included and marketed adequately, as well as others.

Another one refers to driver designs that are backwards-compatible with legacy dimmers. The problem here is complicated and is one of the problems we face in getting light emitting diode (LED) products to dim well is to make certain that the drivers they come equipped with are compatible with dimmers designed for resistive loads. Manufacturers have worked on it, but more progress here is needed. There are two possible solutions. One is being forward-looking where one could define future drivers being compatible with future dimmers and the second path is having new drivers being backwards-compatible with existing dimmers. The research project here would be the latter path.

The next research topic involves methods for predicting chromaticity. There currently is not a consensus regarding chromaticity maintenance. Is a possibility that methods could be developed to address this because people need some kind of method of knowing about relative chromaticity stability.

The last one in this set is methods to better characterize the light area reliability of SSL luminaires. Right now most manufacturers are using 170 lumen maintenance, because there is no metric currently to turn to, but this only reflects the life of a particular characteristic. There are other elements involved including optical elements, coatings, seals, and driver components, so this research in optics is meant to investigate whether there are ultimate methods to characterize the life of a product. One question also pertains to determining a metric to express this not in terms of hours or years so that there is a way to get the relative idea of a metric between different luminaires.

Poplawski: When we're talking about the last topic, are you more interested in reliability or useful light? People often confuse the two. Reliability is during its useful life. Or are you more interested in knowing when the lights will faill—the distribution of their failure rate?

Ledbetter: The reliability methods you are talking about occurring during the luminaire's effective life will still require some metric expressed in hours or years.

Poplawski: One is a failure rate.

Ledbetter: During an expected lifespan, so you still need to know the hours. One of the questions proposed here is to side-step the determination of what the useful life is if you don't know it as expressed in hours or years.

Poplawski: Sounds like you're talking about a "robustness" metric.

Clark: Just a question here as a luminaire manufacturer: Are you talking about this kind of a metric for any luminaire component?

Ledbetter: I think you're right. We're very familiar and comfortable with how long a car will last, but with a brand new technology we need to have some certainty on how long it will last. Manufacturers post L70 values as a surrogate for lifespan. In the interim, there seems to be a demand for something like that.

Clark: If one of those metrics is solder point temperature, that certainly is an accurate measure.

Group C: Lighting Controls

Poplawski: We recognized that one of the challenges looking backwards is that there are a lot of installed control systems that don't do what they're supposed to be doing, but they're still there. There is now significant potential to resurrect existing control systems and to make them more useful. Two projects are involved here. One is focused on the deployed systems out there and trying to determine which are the most potentially useful. The second is how to get manufacturers to develop the necessary systems to make use of these deployed systems.

Another is a research review of failed installations to understand all of the ways that systems have not lived up to expectations. This is not to focus on what features these systems had or did not have, but on why they did not live up to expectations.

In the future or even the near-term you can best take advantage of widgets such as a controllable luminaire if there was a standard way that the widget could communicate with a control system. Even once it's installed, if a system could access the widget automatically, this would speed the transition of that luminaire, so we need to develop standardized equipment profiles for control systems.

A couple of related things. From the demand response (DR) perspective, a number of utilities have talked about challenges of getting the DR signal to the building. If a building has the ability to shed large loads this can be gauged through existing systems, but if the load shed is small, it might be below the threshold for a meter to detect. It might still be worthwhile identifying the load shed, however, so we need research to identify small load sheds during DR events.

Another frequently discussed shortcoming involves user interfaces and programming. So the research project here is to improve the state of the art of the ability to do that. There's a couple of ways, at least, to do that. The more interoperability there is in hardware, the more people focusing just on software can compete within a wide swath of users. It's harder to write this kind of thing up than it is to write up a technology feature, and it's harder to describe what kind of graphical user interface that people want. Maybe the goal should be to create a platform for people to comment on that.

The last two projects help tie-up these other efforts. How can spaces use knowledge of available luminaires and sensors and the knowledge of the space to automatically deliver optimal lighting for a space? The research project is to identify methods and algorithms to process data and develop higher levels of data, such as ongoing occupancy if the traffic is moving into and out of the space, and then to process this data with the ability to operate luminaires and other aspects of spaces and to skip the need for user feedback to optimize performance tailored for each space.

Commissioning characteristics and requirements: Another challenge of existing systems is the gap between what it's capable of doing when fully deployed, and what's needed to get it to that point. An example here would be existing systems where there's not enough time to optimize capabilities. This project would focus on identifying the best practices and requirements to deliver the ideal performance.

Johnson: Did you look at controls for exterior lighting, or mostly interior?

Poplawski: We focused on interior commercial lighting. Some of the thought of our group was that by focusing on commercial maybe you could develop technologies and get costs down so that they could then be pushed to the residential space without paying extra—the increased functionality just exists within the equipment. We didn't' talk about outdoor lighting but there's some transferability there as well, such as interoperability, and this can be leveraged from indoor lighting as well. A lot of this also had to do with dealing with legacy experience of indoor controls.

Johnson: What about the questions between wireless systems versus wired, or self-powered systems?

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Poplawski: We didn't get into that. That seems like something for the manufacturers, or for those who deliver the solutions, to decide.

Grable: I think the issue of implementation and costs for controls is a very interesting topic.

Poplawski: We need a better understanding of how to monetize features beyond systems—this is important, as is scalability. A number of those things we thought that we had discussed really the only way to approach them is through development and deployment, nor research and development projects.

Guglielmetti: It seems there is quite a bit of overlap. There's one research area centered on failed systems and how we go about repairing those, and then there's the question about commissioning. The last thing that people who have failed control systems will want to do is to install more stuff.

Vanderpool: If we have the evaluation and assessment completed as part of the research and development effort, then the trend is a lack of commissioning. That could be just one among a number of things. The goal is to determine the situation in which the failures occurred, and once this is known, to develop better characteristics for future projects.

Poplawski: The group here thought that there were two categories involved in this situation. The first was the lack of knowledge that people have of their own space, and then they installed the wrong system for their space. Then, the building gets retrofitted a number of times, and then the system doesn't work because it's not tailored for the space anymore at all. But with an understanding of the installed system, maybe it's possible that only a minimal amount of things need to be done to the controls to make them functional again.

Strandberg: Decreasing power densities, particularly with the use of more efficient luminaires, means that we're trying to identify the cost-effectiveness of controlling systems with ever-shrinking loads.

Poplawski: We didn't discuss that exactly, but we did hit on some peripheral things, such as the sophistication through which we monetize systems. Another was with respect to DR: should there be a project to develop very, very cheap end-use measurement and verification capability so that true savings can be aggregated?

Group D: Task/Ambient Lighting; Luminaires

Johnson: We were talking about what the real lighting needs are in spectral, spatial, and temporal views. We need to identify what the quality lighting functions are, and then put these in a context of market transformation. We can do all the research, development, and deployment we want, but if it doesn't get to market then it's not a useful technology or effort. It's more about synergy and synthesis with zero net energy buildings, controls, daylighting, and other systems.

One thing we need is demonstrations focused on offices, laboratories, and other such spaces.

Clark: I'll focus our top six research requests to maybe stimulate you all. If the purpose of lighting is to create the feeling of the space, then very first question we ask is about the metrics, including skin response, eye response, blood flow, etc., that can be used as indicators of satisfaction and comfort. Right now we just have surveys. We need objective measurements.

Next, can those human-factor satisfaction metrics be linked to luminaires metrics? If so, can these luminaires metrics be linked to a system of qualifying these luminaires under a certification and rating system?

Request number two was to review research with other research programs, such as the Heschong Mahone group survey. Can you show student performance improves by learning under the Integrated Classroom Lighting System (ICLS) classroom method? My understanding is that there are enough installations of this system to provide the data we need, related to control installations, to be statistically serious. This will enable us to measure the kind of performance that no one else is looking at.

Number three is really a set of questions that comes with respect to optimizing work environments to understand the way we are doing work in the workplace. This is changing as rapidly—more rapidly, in fact—than lighting is changing.

The workplace doesn't look the same, so what is the evolving workplace of the future? We don't know what's going on, including the environmental requirements and the needs for human interface with shared lighting systems.

Number four was the push for the next generation bi-level luminaires based on percent of light delivered. Right now we say it's on or of, but we don't say that humans want 15 percent, or 18 percent, or something else, for non-occupied areas. If there was this knowledge, SSL technology would let you drop about 95 percent of the power load in every stair and corridor, right now.

Number five was about designing luminaires that best take advantage of SSL. Can we get agreement on the life cycle costs of SSL? We need standards on this.

Number six was a request for a best practices guide for building retrofits. We don't have this. We are really missing out by not documenting what works and what does not.

The last one involved metrics for comfort and satisfaction for the luminaires.

Poplawski: So, given the different types of luminaires that would be used to implement task/ambient systems, would it be worthwhile—or did you discuss how you could relax certain lighting requirements for one luminaire or another, since they're serving different purposes?

Clark: We talked about that a bit, but it came down to understanding if we could hang that tradeoff on hard data—we would really need to know. We'll rely on people like you to find the data. It's a great question and that's where the interaction of the metrics with the systems comes into it.

Patterson: As we move down the curve for energy use, we need to understand this better.

Clark: We haven't ahd this kind of change since fluorescent lights in the 1940s.

Siminovitch: One of the issues we discussed was having the task/ambient lighting as a system within the building, which is itself a system. We don't have to wait for the demonstration or the research and development to start.

Ledbetter: Did you all discuss what research could be done that was raised by lighting designers?

Siminovitch: That's why we talked about demos because without a demonstration you can't show what works and what doesn't.

Clark: I think where the discussion went 'round and 'round was regarding the idea of a new aesthetic, and as soon as you get there, there is a debate about how things work, and then we're back to discussing energy versus art. Once we know this data, then the designers will use that.

Patterson: There's a ton of research being done on how the workspace is being used and how flexible or static this use is. There's rather significant stuff going on here but it is in the architectural industry, not in lighting or engineering.

Clark: You're right, but at Microsoft, Google, some others, they've been moving so fast recently.

Patterson: One of the dynamics that is changing is the churn rate in the workspace. We think of buildings as 100 year old entities, but often the internal space churns every three years or less, so a lot of lighting design depends upon the building, how it's used, and how it has changed over time. There's no single answer here.

Group A: General Lighting

Patterson: I'd like to follow-up from the last group, because we started in the same vein. There are some characteristics that are used, such as satisfaction, and other characteristics that are left out because they're not studied in a way that they can be turned into a metric for a design tool. One of the gaps needed to be filled is to develop tools for designers, but this can't be done until the characteristics of lighting needed is known. This changes with the applications—exteriors, lobbies, laboratories, etc. One of the characterizations of lighting that is important is the physics, along with the behavioral aspects, and also in the application of what's being done in the space and how lighting effects that.

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Our next area was regarding the fact that people talk about trying to add value to lighting to rationalize certain improvements to quality and use this to rush to energy efficiency, because this is more easy to achieve than biological or qualitative measures such as health, comfort, and performance. These kinds of measurements are not understood well, or if understood are not monetized to include as one element within an energy efficiency investment.

On to one thing that is more nuts-and-bolts: You heard presentations yesterday about plasma lighting, and there are a couple of items in this roadmap about plasma lighting—to apply it where it's beneficial for energy efficiency and make sure that it doesn't get misapplied. If you look at the longer-term window, there is a possibility of characterizing things that are new based on old technologies and tools that don't apply to new technologies, and vice-versa. Characterizing lighting for both old and new technologies, and understanding that this is potentially difficult when dealing with legacy and new technologies.

One of our research and development programs pertains to luminaire dirt depreciation (LDD), including self-cleaning luminaire reflectors, which leads to some sort of study about technology and LDD.

On the electronics side—and this also stems from climate change, zero net energy goals, distributed generation, and renewables—is the need to look at power conversion efficiencies and how this effects various technologies, electronics and substrates particularly within the realm of lighting. For example, not converting thousands of volts but smaller voltages. There are probably some new technologies that are not getting attention in this area, such as alternating current and direct current conversions in a total systems view, and this includes plasma lighting as well.

The other one is flexibility regarding the churn rate in buildings, such as repurposing and retrofitting of retail and other spaces. This has a significant impact on lighting. We've heard such things as "why do you put so much light in here," and we say it's because we don't know what the space will be used for, so people are afraid to design a space with flexible systems, because it's expensive to do so. This includes also plug-n-play systems and lighting arrangements for flexible configurations.

Nock: I understand the need for flesible lighting and controls when space use is not defined. I didn't follow what you said, however, regarding connectivity between plug-n-play systems.

Patterson: A typical hard-wired system costs $300 for labor. Plug-n-play in this situation means installing so as to minimize the need for systems reconfigurations. Particularly if we go more in the direction of SSL, we'll see increased lighting efficacies. If the velocity of technology is going up, we don't want to over-build. Another thing is that we want to make sure the installation can be changed out quickly. It's the ability to churn the technology at the rate that the technology can bring enhancements to the room. In the industry we don't usually let people change the lighting. Why not? Because it's too expensive to enable this for a given space. We don't set up our systems so that they are easily adjusted. For example, you put a sensor into a space and that works, but then someone puts a shelf in front of the sensor, so you'll need to move the sensor but that might cost $400. We need systems that can readily handle the many uses or that can be easily modified.

Papamichael: Did you also discuss the metrics that we use? One of the biggest problems that we have in lighting is that the metrics we use, such as work plane illuminance, are not as relevant to comfort, and thus not as useful. Moreover, the units that use, such as the lumen, are not as appropriate, as they represent the sensitivity of the fovea and do not account for peripheral vision.

Patterson: One of the things we talked about is light measurement. You can believe that people will be able to adjust their own lighting needs; another way to approach this is if sensors and controls can do this automatically. More and more systems take into account all of this variability, and this becomes a complicated model, and perhaps that is best handled in the software of the control systems. This is all related to where people are in the building, how many, what they're wearing, etc. We talked about characteristics that we need to understand are not the traditional characteristics. We need to have the right understanding of what the characteristics are and how they're measured.

Papamichael: I asked if illuminance was a good metric.

Patterson: We discussed how we could measure this and the assumption was that the way we're doing it is not adequate.

Grist: I have a direct follow-on to this. We need to boil the metrics down to something that is useable. We don't even know what they all are, but we know what some of them are, and we need to get the data in a way that is useful in the field.

Clark: Did you happen to discuss breaking the luminaires and the drivers into different components? I say that because in looking at the luminaire, it can operate for 250,000 hours, and if we're looking at changing the driver and modifying the granular components, we don't need to change the luminaire.

Patterson: We didn't talk about that to a great extent, but certainly the different components are important.

Snyder: Just to ask for clarification, among the metrics that have been developed, such as Relative Visual Performance and the Unified System of Photometry, I wonder what you feel has been lacking?

Papamichael: What have they been based on?

Snyder: They've been based on experimental data.

Papamichael: Some of these are like acoustics. If you're studying different things in school, the subject matter may require a different system of acoustics. If you're studying different aspects of lighting, maybe the metrics need to be different and calibrated to different tasks that the space is being used for. For example, lighting needs in the cafeteria differs from needs in the laboratory. The color and the intensity in these places may be optimized differently.

Papamichael: My question is more fundamental than that. If we get a room with all dark surfaces (floor, walls, etc.) with troffers, we may still get the required illuminance on the work place, but is that a room that anyone wants to live/work in?

Group C: Daylighting

Papamichael: The problem we had was that our work involved things that were kind of in the area of controls, kind of in the area of envelope, and kind of in the area of luminaires. We started by creating an outline on our own and working from there, and then transferring this information from our laptop to the posters on the wall. There were already three areas of identified research in the Portfolio, in daylight harvesting, the sensing itself, and commissioning. In this latter area (commissioning) we have two separate operations. The first is the calibration of the system to match the space, which we have now automated. The second is the adjustment by the occupants to match their needs. A 25-year old has very different lighting needs than a 55-year old.

The one for daylight sensing and controls is integrating technologies. The controls folks addressed this in some way. We think that integrating technologies in terms of smart luminaires and other smart objects, such as windows might be the best way to move forward.

The second was daylight cost assessment. One of the biggest barriers in daylight design is that we cannot simulate complicated skylights or windows with blinds. We need tools to simulate fenestration performance including controls within the models. Also simulating electric lighting controls such as sensors—where they will be and what they will be sensing. This is moving along.

We also have assessment in field testing and measurement and verification—did it do what we expect? We need to agree what to measure for fenestration and elect lighting and controls, including HVAC. Also measure occupant response and acceptance.

The third area is the human factors area. The occupant acceptance of controls of fenestration and electric lighting controls, and what about overrides—if we allow these, then how do people interact with them? There was another one in the existing roadmap that was talking about light pipes, and that is part of core lighting/sunlighting, which is also related to the building envelope roadmap. There are four issues related to core lighting systems: How do we collect daylight; how do we transport it to the space we want to illuminate; how do we deliver it in the space; and how do we integrate with electric lighting controls to get the electric lighting energy savings.

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Finally, we think that we need to find ways to address interdisciplinary collaboration. This might not be a technical research area, but one can see it as process research related to how can we actively bring in different disciplines into the design process?

Thompson: Did you address the idea of bringing daylight further into the building, such as light tubes and light pipes?

Papamichael: That is part of the core lighting aspect that I just mentioned. We see more and more technology for this in the market.

Lane: On the software side, when I was reading it here it seems like it's getting more un-user-friendly. How do you create all of the complexity and still have usability, or is that focused on higher-level designers and engineers?

Papamichael: There are two different ways to do that. One involves the capabilities, and once we have these developed we can then see how we might simplify them. The other issue is the need to have interdisciplinary approach to be able to combine architecture, engineering, health, and other areas. A single brain can't do all of these. One way is to incentivize with money to bring parties together. It's good to have easy-to-use tools, but I don't think that there will be tools of appropriate modeling capabilities and accuracy that the general population can use.

Guglielmetti: OpenStudio is aimed from top to bottom. It's an issue of complexity: it's impossible to take something as complicated as Radiant and make it easy to use. Complex fenestration and the like takes complex tools to model. Our answer is that we provide the tools to the experts, and the work we're doing in FY 2013 is for researchers to take the tools to create large data sets to quantify energy benefits so other stakeholders can put in location- and building-type-specific information and get a high-level understanding of what's possible. We're not looking at developing an iPhone app and selling it for a dollar to have everyone be able to use it. For both a building-by-building and sector-by-sector approach, this will allow people to have a sense of what's possible and hopefully then entice them to hire a lighting designer.

Clark: One observation here. What's really intriguing to me is to see outside the room here that trees are moving, the sun is shining, it looks great out there. I'm not sure that the architect who designed this room cared about energy harvesting, but bringing in the outside to this room. The architect may have justified the costs of these big windows purely on aesthetics, not on any concern for daylighting.

Guglielmetti: That's the issue with some of these approaches—monetizing some of these considerations so that architects would want to implement them for reasons other than aesthetics.

Savage: When Eric brought up the point that as the power use diminishes, it effects how we look at controls, it occurred to me that when we look at this list it's populated partly by utilities. Our company makes direct current systems for renewables. There is a crossover point where some electricity comes from the solar technology where if solar becomes cheap enough then it might not be cost effective to do that. It's great to hear how control and power considerations are coming together.

Roadmap Portfolio **re-organization discussion**

Lane: I'll start with questions. It appears to me that the way you have the lighting product and service area organized is that you just suggested the most convent bins. It doesn't look like a rational way to comprehensively characterize the full scope of research in lighting. It looks like research topics that fit pretty well with the ideas that you've been given to date.

Binus: Tom [Reddoch}, you were there in the first workshop, and maybe Charlie [Grist] was as well. We worked on the board and came up with the product and service areas first, and then we brainstormed technology characteristics, and then broke into work groups of folks who helped formulate performance criteria and capability gaps. I don't have a really good memory—

Grist: Yes you're right, the organization that we're now working with is an artifact of us groping our way. I don't think anyone is married to this organization.

Binus: We would like to revise this organizational structure and we're soliciting comment all this week so that we can do so from an informed place.

Papamichael: The key word is rationality. It would be very useful if we reorganized this in a rational way. Every element should have the same nature. One question I have is that the Task/Ambient roadmap is a *strategy*, while Luminaires is a *component*. What kind of portfolio is this supposed to be—technologies, strategies, something else? Maybe this portfolio is about both of these at the same time, but ideally it should be only about one, and this should guide the content of each individual box.

Werling: Following what Kosta has said, Joshua, you talked a number of times about trying to get away from the "widget-based" approach, and I'm assuming that you mean by that getting better things to the marketplace. I'm wondering what the alternative is to that kind of approach, such as changing people's attitudes.

Binus: Custom project come to mind. We're a utility, and our colleagues who work in energy efficiency programs implementation are more focused on widgets which enables them to replicate the installation of equipment with a known energy savings. They're not necessarily focused on a systems approach.

Werling: I was hoping for more clarity.

Grist: Joshua, maybe one thing that you a could confirm, or not, is that I thought that the original request in developing this roadmap portfolio was to find technologies that could be funneled into programs implementation?

Binus: That is part of it.

Grist: If that's clarified, it could serve as a different way to organize the portfolio. If widgets for the program team is a part of the purpose of this effort, it's a different focus than more intensive research and development. Time is the critical factor here.

Snyder: I developed a few slides for my presentation on the way that I personally conceptualize energy efficiency. First is the different techniques, such as design, controls, and luminaires. Then there's the implementation part, the way that we move the technology into the field—rebates, education, design tools, etc. The third area to think about is the sector that you want to get in to. I know this is a technology roadmap, but there are techniques involved as well.

Poplawski: My question also follows Charlie's comments. The effort here is focused not on developing programs to deploy technologies, it's to help feed technologies to the Emerging Technologies team, right?

Binus: There is a little cross-over. Yes, we are interested in deeper research and development, but we do have some items in our portfolio that are emerging technologies, but only if these are facing technology barriers.

Nock: After addressing Kosta's point, is there a strategy that would be applied to all roadmaps? Is there something that would work for all of the different categories, rather than a different approach for each roadmap?

Patterson: So, for example, general lighting strategies in a household would be drastically different than such strategies in a factory?

Nock: Right. If you took any of those categories to serve as the fundamental basis for your organization.

Poplawski: Some elements will be in all of the different roadmaps, such as human factors.

Patterson: Well, even that changes in different segments and sectors. I want a strategy aimed at residential or a certain kind of commercial building, but it's also different within various parts of our territory—such as data centers, whether I have those in my territory or not.

Poplawski: It sounds like you're arguing for more narrowly-defined scopes for each roadmap.

Patterson: The strategy changes for different types of buildings.

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Lane: Looking at the organizational structure here, the thing that stands out to me and that I've heard in other settings is that everything is in vertical silos. The horizontal connections that are missing, how do they effect not just the lighting area but the other things, such as HVAC?

Binus: I completely agree, so how do we organize this in a way that makes sense?

Lane: An idea comes from American Society of Heating, Refrigeration, and Air-Conditioning Engineers' (ASHRAE) Advanced Energy Design Guides, just as a construct to refer to.[1] Developing these involved people from each discipline to talk about these ideas. Instead of thirty or forty people solely from the lighting area, if you drop two people from each discipline into a group, then you start to see the horizontal connections forming between the vertical silos.

Binus: That's a great idea for workshops, but in terms of an organizational structure, how do we do it?

Johnson: Start with the end in mind. With the vertical silos of widgets that we have currently here, what we're losing is where do they go? It's only implicit in the current roadmap structure. In the top swim lane, the drivers are very clear—we're trying to substitute energy efficiency for generation and to counteract climate change. We're struggling with this in California as well. We started focusing on best practices, and these entail integrated systems technology within an application. One can get in to arguments about the various applications once the systems get implemented. There's no use getting in to this unless you understand the market. The end result has to be market transformation or what's the point? If you do all this on best practices, that could be an organizational principle that goes across all of the silos and gets you where you want to go.

Snyder: I had a follow-up comment about my earlier statement: I was advocating for a way to categorize things, not to make additional silos.

Ryan Fedi: Just to follow-up this sentiment of connecting across categorize and what we do about the integration issue, in talking with Terry Oliver about this, he said that hopefully there's enough content in the boxes to reflect the interconnections, and this would reflect the maturity of the roadmap when we see how they all work together. A lot of you work with this as well. An example is from our Transmission roadmap, that once we had these boxes on the page we started to see how they all fit together. Here I think a similar thing will happen, in that once we build up the content we'll see how they all fit together. Somehow we might find a way to solicit comments from you all on our process and how we can make it better.

[1] See http://www.ashrae.org/standards-research--technology/advanced-energy-design-guides.

Appendix A12:
Building Design & Envelope Workshop (Sep. 26, 2012)

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September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

BUILDING DESIGN / ENVELOPE ROADMAPPING WORKSHOP

Wednesday, September 26, 2012 | Adams / Jefferson Room, 1st Floor

Purpose

- Review/Confirm/Revise technology features and R&D programs for all residential and commercial roadmaps in the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio.*
- Prioritize (for deeper study) a sub-set of emerging technologies.

Facilitator: Joshua Binus (BPA)

Support: James V. Hillegas (BPA); Ibrahim Iskin (PSU ETM); Rob Penney (WSU EP); Ellen Petrill (EPRI); Jennifer Williamson (BPA); Jack Zeiger (WSU EP)

8:00 am	Summit Welcome and Orientation (Cascade Ballroom)
8:30 am	**Welcome and Introductions**
9:00 am	**Orientation:** Background, Description of Goals/Process **Divide into Subgroups**
9:30 am	**Review / Confirm / Revise Technology Features and R&D Programs**
	For every roadmap "thread," each subgroup will execute the following: **Task 1:** Review existing Drivers and Capability Gaps (revised on Aug. 8) **Task 2:** Review/Confirm/Revise Technology Features **Task 3:** Review/Confirm/Revise R&D Programs
11:30 am	Plated Lunch (delivered to room)
12:15 pm	**Continue subgroup tasks**
2:45 pm	**Subgroup Reporting & Group Discussions** (captured via verbatim minutes)
3:45 pm	**Next Steps:** ▪ R&D Program Prioritization ▪ Revisions to *Roadmap Portfolio* Organization Structure ▪ *Roadmap Portfolio* March 2013 draft
4:15 pm	**Emerging Technologies Prioritization**
5:00 pm	**Adjourn**

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National EE Tech Roadmapping Summit

DoubleTree Hotel, Portland, Oregon ~ Sep. 26, 2012

Building Design/Envelope Roadmapping Workshop

Minutes of the sub-group reports & discussion of the *Roadmap Portfolio* organizational structure – REVISED 2:45-4:15 p.m.

Group A (Retrofit and New Construction Windows; Insulated Shades; Daylighting)

1. Charlie Ćurčija (Lawrence Berkeley National Laboratory (LBNL))
2. Jim Larsen (Cardinal Glass Industries)
3. Kosta Papamichael (University of California Davis California Lighting Technology Center)

Group B (Retrofit Insulation; New Construction Insulation; Transformative Building Materials; Eliminating Home Penetrations; Air Sealing; Infrared Scanning)

4. Todd Currier (Washington State University Energy Program)
5. André Desjarlais (Oak Ridge National Laboratory)
6. Peter Douglas (New York State Energy Research and Development Authority (NYSERDA))
7. Mark Modera (University of California Davis Western Cooling Efficiency Center)
8. Sriram Somasundaram (Pacific Northwest National Laboratory)
9. Theresa Weston (Dupont Innovations)
10. Sarah Widder (Pacific Northwest National Laboratory (PNNL))

Group C (Zero Net Energy; Manufactured Housing; Solar/Smart Roofing)

11. Ammi Amarnath (Electric Power Research Institute (EPRI))
12. Ren Anderson (National Renewable Energy Laboratory (NREL))
13. G.Z. (Charlie) Brown (University of Oregon)
14. Jack Callahan (Bonneville Power Administration (BPA))
15. Rob Hammon (Consol, Inc.)
16. Tom Hootman (RNL Design)
17. Karl Johnson (California Institute for Energy and Environment (CIEE) at UC Davis)
18. Michael Lubliner (Washington State University Energy Program)
19. Paul Torcellini (National Renewable Energy Laboratory (NREL))

Group D (Deep Retrofits)

20. Johanna Brickman (Oregon Built Environment & Sustainable Technologies (BEST) Center)
21. John Jennings (Northwest Energy Efficiency Alliance (NEEA))
22. Lew Harriman III (Mason-Grant Consulting)
23. Rem Husted (Puget Sound Energy)
24. Michael Little (Seattle City Light)
25. Gordon Monk (BC Hydro)

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26. Pete Pengilly (Idaho Power Company)
27. Dave Roberts (National Renewable Energy Laboratory (NREL))
28. Eric Strandberg (Lighting Design Lab)
29. Omar Siddiqui (Electric Power Research Institute (EPRI))
30. Alecia Ward (Weidt Group)
31. Eric Werling (U.S. Department of Energy Building America Program)
32. Amanda Ayoub (Portland Energy Conservation, Inc.)

Minutes by James V. Hillegas (Bonneville Power Administration)

Group D (Deep Retrofits)

Harriman: I'm going to start by saying that a lot of our projects come from big-issue items that we've added. Most importantly is the thread that comes to the need for measured and persistent results to provide meaningful feedback—measured results. To begin with, we had difficulty differentiating between the commercial and residential sectors, but there are a lot of parallels, at the R&D project level; at this level, it's important to keep them separate, though the Technology Characterstics, Capability Gaps, and Drivers might pertain to both sectors. The first is measured results: Did these projects work, and if so, how well and for how long? When we look back at work that's been done to date, did it work? What can we learn from this?

The next R&D project is our call for a roadmap for deep building retrofits. There's a lot of questions in deep energy retrofits, so the industry needs to have a roadmap so that people can intervene proactively in the retrofit process. Josh Plaisted of EchoFirst provided a lot of good examples in the panel presentations this week—if we were to put his brain in a roadmap, we'd be much more successful in this area.

We also need an assessment tool characterization and to provide guidance for use of this tool.

Jennings: Characterization and rating assessment tools.

Harriman: Right, we need to identify where the shortcomings are in these.

Integrated deep retrofit pathways and packages: This pertains to packages of retrofits that will work and be effective, to be guided by the retrofit roadmap I just mentioned so that the packages work and are economical for everybody.

Databases: We need comparative data and to populate the databases with this data. We've got this stuff out there, but we need to put it into a centralized database to make it all more accessible to more people so that we can do better work.

Jennings: And/or ways to link across databases—how can we find commonalities?

Harriman: Right, interoperability. If not a translater, then across the database, so that we can integrate across institutions and regions.

Market characteristics and the study of benchmarking tools: What are the tools now available?

Jennings: This is the same idea as a rating, but focused on benchmarking tools. How do we know what tools are good, for example, and how do we know what the tools do in a consistent manner?

Harriman, Ok, another one is the market evaluation of energy efficiency labeling. We need to figure out what the value of these energy rating systems are in terms of the market, to help accelerate adoption of energy efficiency. If we can quantify this, such as in North Carolina where they did so and found out that the only difference was in choosing EnergyStar or not. What is the value in knowing that?

Those are the highlights.

Werling: There is one thing that you didn't mention, and that is about establishing more standard criteria for labeling and rating and specifications and things like that, so that it's not a Wild West type of—

Harriman: So we don't have labels that don't mean anything?

Werling: There's uncertainty on the ability for the tools to predict energy efficiency measure savings. There's not a whole lot of after-it's-done measurement, not a lot of certainty on how good the tools are in predicting and we don't know that much on what happens in the marketplace in terms of how energy efficiency improvements are valued or not. The theme that underlies all of this is from research all the way to market adoption, can we get a better handle on the data and incorporate it in the infrastructure? Not just better predictions and measurements, but closing the loop in the whole thing.

Roberts: I'm not sure how it trickles through, but there's a need for discussion on the need to look at whole systems rather than at the individual technology level, at the house and beyond. Programs are often constrained to look at measures instead of whole buildings.

Harriman: Were there commonalities among the other groups regarding a focus on measurement?

Somasundaram: Did you consider cost effectiveness in any of these aspects?

Harriman: A lot of the modifications to the Capability Gaps that we did had to do with being able to measure cost effectiveness.

Siddiqui: There was a driver related to cost effectiveness, but I worried that there needed to be an explicit mention of the owner in terms of cost effectiveness—there's a lack of a clear measurement for cost effectiveness as it relates to life cycle or enhanced measurements.

Torcellini: Several of the groups had this issue differentiating between residential and commercial sectors, and we had this also. Is there any attempt among your group to try to map the common pieces between those two areas?

Harriman: We had a detailed conversation about the roadmap on the residential side, and then when we got to the commercial side, we found ourselves saying "do this, only for the commercial sector instead of for the residential." We didn't then discuss how to mesh these back together. The single difference was on the one Capability Gap where we talked about utility needs for measured data for various reasons—they don't want to share the data. This is a commonality that both the residential and commercial sectors deal with, the utilities not wanting to share their data.

Torcellini: There's strategies for commercial envelopes that use technologies that are similar to residential technologies.

Harriman: We didn't talk much about that.

Werling: In side discussions we talked about that to some degree, and to follow Paul there hasn't been a lot of communication between the needs and commonalities of these two sectors, and maybe that's a need for an entire research project to determine such commonalities.

Harriman: Is what you're saying regarding the technical similarities between these sectors is that they exist but that these haven't yet been identified?

Werling: We learn something by comparing these sectors, that's a good question.

Harriman: We were more concerned in our work today with economic and other issues, but we didn't' tie-in the technical similarities between the sectors.

Siddiqui: There's also an integral organizational issue within each agency, in which there are residential and commercial teams and programs that become siloed; this is an artificial division.

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Pengilly: We're trying to do some multifamily that meshes the two.

Torcellini: There's a continuum here. There's a good opportunity here to do that and not to create artificial silos, and this work can help the Department of Energy and others.

Monk: I didn't write-up the deep retrofit multi-unit residential building (MURB) project that BC Hydro has been involved with, but we will publish a series of reports starting next year through 2014 as the project moves along, and it may help inform similar initiatives in your own territories. We are also completing finite element analysis of envelope assembly details to inform our New Construction Program.[1]

Group B (Retrofit Insulation; New Construction Insulation; Transformative Building Materials; Eliminating Home Penetrations; Air Sealing)

Douglas: New building insulation: We spent a lot of time working on Technology Characteristics for this roadmap. A lot of protocols and assessment and measurement tools work is necessary, and you want to separate that from technologies that get applied for end use. The big things that we needed up with was the need for more environmental assessment for insulation materials.

Another interesting thing that emerged was trade-off analysis. How much money do you put into the envelope though you know that it will leak?

The two real technology agendas that we found were more on the area of tunable materials—properties that may be able to dial up or dial down at the site.

The other area of research involved phase change materials in insulation, and generally managing the thermal transience.

Widder: One thing I'll note is that we re-arranged our roadmaps. We started with six and now we have three. We got rid of the Eliminating Home Penetrations and the Transformative Materials roadmaps. We kept new and retrofit insulation separate though there are a lot of similarities between these two roadmaps.

The needs depend on the condition of the envelope. There's a different cost effectiveness problem that exists in buildings that are typically done on a component basis, where as design in all-inclusive. Materials include fill-in, developing excavationless technologies to provide interior insulation for foundations, and work is being done by the DOE's Building America program on this.

Talking about cost-effective high R-value materials that can be retrofit on the inside of the building rather than blown-in. There's also an insulating sheet rock alternative. Also, building materials that could go on the exterior on top if existing cladding material. This was a similarity shared with the New Construction Insulation roadmap—different ways of attaching high R-value materials to existing siding systems, because that's typically where a lot of cost comes from in having to remove siding.

We photocopied our cost sheet and put it on all of them, so there's an emphasis here in all materials and technologies needing to quantify the cost effectiveness—sometimes air and water barriers are the same, sometimes they're not. It is very important to compare and evaluate cost effectiveness of these different approaches.

Modera: What we did was take six roadmaps and knock them down to three. This new roadmap is titled Retrofit and New Construction Air and Water Management. This idea came out of our session yesterday. You have an air barrier and an air tightness—the latter linked to air and the former linked to both air and water. We need to come up with some sort of diagnostics. I asked about this yesterday and did not get an answer. So, we need to find out how to understand how the barriers keep both air and water out of the building.

[1] See BC Hydro, "New Construction Program," http://www.bchydro.com/powersmart/builders_developers/high_performance_building_program.html.

We also built on something that was already here—affordable air sealing. This goes beyond the above to include how to automatically seal all of the leaks and also to find all of the leaks and mark them in some way. There are two things that are new that have not been part of this discussion. One was the idea of self-sealing envelopes. What happens if the building shifts, can you have a system that will allow the building to heal itself?

We had pulled in not just the idea of air sealing, but also by designing buildings so that we don't have to do much air sealing. One research project focuses on wireless technologies—are there wireless systems to help eliminate all the various penetrations? We didn't have any good ideas for wireless plumbing, but that's your job.

Torcellini: You had mentioned the environmental impact of the insulation pieces. Our experience of that is that environmental impacts occur with the manufacturer, the installation process, the deconstruction; did you focus on all of these?

DEsjarlais: Yes.

Torcellini: When you install [did not catch this entire statement].

Anderson: We're starting to get worried about people's ability to over-seal homes, to get buildings so tight that systems are hard to operate without pressurizing the house. Do we need to define limits on how tightly we seal, or do we need a whole new set of systems with broader benefits?

Modera: My opinion is that we have a whole new roadmap tomorrow where they will fix all of this. One the vent side, obviously there's makeup air for when you turn on a range hood, etc. It's true that you could create situations where the buildings are so tight that you have problems. The key things are that the systems should be robust enough to handle this. I think it's easy to make it tight and adjust the ventilation accordingly, rather than the other way around. I houses, there are operable windows. In Europe they've been doing this for a long time where there's a little lip in the window so that they can add leakage back in in a controlled manner.

Anderson: Maybe there's a need for a research project to ensure the tie-in with other systems. For example, installers might not know of this, but the other experts would know the parameters and specifications.

Harriman: I see the need for tools to quantify moister for a wall without having to dig into the wall. This is an issue in buildings in terms of both durability and energy use. I'm very discontent with the current state of moisture content analysis in a non-destructive way. Should we add this to the roadmap?

Modera: We had a project for diagnostics where the barriers were, but did not include the moisture of wood. I think that's a good idea.

Harriman: It could be used as a prophylactic and for diagnostics, particularly in the Pacific Northwest.

Brown: I have a comment: we're looking at how buildings contribute to diversity and the amount of microorganism.

Ćurčija: I agree that sensing both thermal and moisture is extremely important. The way we could take an infrared camera and get thermal measurements, we need to be able to do the same with moisture. It would be possible to construct a radar system that would detect moisture in the wall.

Harriman: The Israelis have this kind of technology, and a company in Massachusetts has this as well, radar-based detection, but it is not commercialized yet.

Group C (Zero Net Energy; Manufactured Housing; Solar/Smart Roofing)

Torcellini: We had a number of different areas. The first was that we changed Zero Net Energy Homes to Zero Net Energy Buildings. One of the key things while looking at the drivers for this area was, why would people even do it? Corporate responsibility is driving some of this, and in this way this area is somewhat different than other areas. This

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one here is about integration. We talked about the definition of Zero Net Energy, even talking about better than zero energy—is it appropriate, and how far can we go?

On the matter of business cases, what will utilities do with all of these zero net energy buildings? How will zero net energy effect the transmission system? We also look at the market barriers to zero net energy.

Codes typically have been incremental, pushing at the bottom end. Can we re-think the codes as a zero net energy code that places could adopt separately? What are the different pathways to get to zero net energy buildings?

We also had some of the component areas such as solar panels and predictive controls. Some of the controls-related discussion was somewhat more general—how do we design the controls for net zero energy buildings, how do we get better over time? We also discussed modeling—do we have the right models to do zero net energy buildings?

We also had other areas such as smart plugs—are they needed, and how do we deal with plug loads? There were some topics here regarding alternating current (AC) versus direct current (DC) in buildings. If you eliminate some of those conversions, what kids of appliances are needed, and then what kinds of codes are needed?

Also involved in the AC-DC discussion is the question about how efficient can we make these systems? How far can we go from best of class today, from refrigerators all the way down to smoke alarms? There are lots of alarms out there, so getting them to be more efficient could have a big impact.

Then there's the design process around zero net energy buildings—how do we procure and deliver this to the marketplace?

Lubliner: We realized that when we talked about manufactured homes, we're talking about systems in the factory, so our approach could be broader than simply modular homes—we could include panelized systems, construction-integrated systems. This spans residential, commercial, and institutional buildings. It's broad.

Looking at the automation and the test bed study we wondered how the assembly process can be enhanced to achieve zero net energy homes, or at least move significantly in that direction.

Charlie was talking a little about the opportunities involved in time and motion studies to assess the benefits of improving the construction process. Graham and I want to go to China so we can look at manufactured housing over there. We've talked about how in the USA we focus on least-cost, and in other countries they focus on quality, and how can we look abroad to implement these kinds of improvements to North American systems to make them more energy efficient and also more affordable both to buy and to operate.

Parker: This would provide a platform for quicker integration of new technologies. Right now it's pretty standard what is put into modular homes. If you could integrate something like DC power or phase change materials, you can integrate that into modular homes—maybe easier to integrate into this sector than in others. You can let union people do it and then roll it out and put it together on site.

Lubliner: Iv'e been focused on U.S. Department of Housing and Urban Development (HUD) standards being developed with the DOE that will dramatically transform the efficiency level of manufactured homes. This will really impact utilities because lots of these homes have electric water heating even if they have other gas appliances. We're looking at where the existing HUD criteria and the standards are, and where there might be the ability to integrate emerging technologies into the code—what are the gaps? We just recently approved tankless water heaters in HUD housing. You couldn't do this before without a special permit. WE need to scope these technologies and the gaps to encourage introduction of these technologies into mainstream manufactured housing.

Anderson: I have a comment. Zero net energy in general has a large utility integration component that needs to be looked at. These are grid-connected, so that means that defining what the hookup costs are needs to be understood so that there can be business models that work.

Somasundaram: Related to integrated homes, I wonder if you've considered transportation interfaces as well?

Torcellini: That really comes under the boundaries and metrics discussion—what do you and do you not include? People will come to me and say that they've been saving a lot of energy in their building because they've outsourced all of their data center to the cloud. There's a long list of how much do you want to bite of in the definition.

Widder: One thing that blurs the boundary a bit are electric vehicles, and trying to understand how this benefits the zero net energy load benefits of the home.

Hammon: It's not that much different than putting a fountain in the front yard, or installing other decorative things that use energy. I think we're drawing the boundary on the house itself, because there's plenty to dot there. It's very interesting to include the car and other things. The short answer is, however, that we didn't include these things in the roadmap.

Widder: The car could be a form of energy storage.

Torcellini: It depends upon how it's defined, and that's one of our research questions.

Somasundaram : As long as this is in there. Particularly in the Pacific Northwest, there should be a research project to gather this kind of data.

Siddiqui: Regarding metrics, was there any discussion about alternate or other metrics beyond zero net energy, such as zero net peaking or zero net carbon? Is zero net energy the be-all, end-all that we should be focusing on?

Torcellini: Maybe the term is not necessarily zero net energy, maybe its zero net something—and the "something" is the metric, such as the cost, source, site, conditions, etc. This can be part of it. One of the cautions is that we've got to be able to measure things, and we need to know if what we measure has an impact and how it shapes the situation. It is different in the Pacific Northwest than in other areas. If you identify the metrics, then people will figure out how to beat the test of these metrics. This is complex but an important point.

Anderson: We do have a research project that addresses the cost/benefit of what we're trying to get today.

Werling: There's another dimension I haven't heard about yet within the context of trying to define metrics that we can agree on. We're obviously talking about the research side and understanding the technologies, and only implying the policy side of things, be we also must consider the importance of the market side of things. How will people buying buildings react? One entity we need to connect to is the Net-Zero Energy Home Coalition (http://www.netzeroenergyhome.ca/), a relatively new entity in North America. At DOE we've been talking with them, and they are pursuing the question of what is the definition of zero net energy? They're not sure they've completely resolved this but there is a lot of benefit if the scientific community weighs-in on this question.

Torcellini: One of the drivers we had was the growing interest in personal energy independence, which kind of throws out the idea of cost effectiveness in some situations—this kind of approach prioritizes energy independence over costs in many cases.

Hammon: We've also had a research project identified looking at the non-energy benefits of these things.

Hootman: Viable certification processes for this will also be needed. Leadership in Energy and Environmental Design (LEED) is a good example of having a rating and certification system that people can aspire to.

Werling: That's on their list of things to consider.

Lubliner: On Monday we talked about when is it the opportune time to intervene with a retrofit measure in terms of the life cycle of the home, regarding appliances or envelope or other measures. For example, say after twenty-five years the owners are ready to change the siding on a house. If they look at the same time at the windows, it would be more cost effective to replace both at the same time. Was this part of the discussion, looking for opportunities that present themselves to integrate modifications and retrofits into the process?

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Harriman: That was an essential part of our discussion, the importance of understanding those points where it makes economic and cultural sense. This is what we need that roadmap for, in the home remodeling process, as opposed to the economic aspects or life cycle process.

Anderson: To build on these ideas, there's eternally a set of cost tradeoffs that are among the economic drivers and that are difficult to achieve currently in the retrofit process. One of these are the benefits of downsizing the HVAC system by improving the envelope. There's a need to improve the envelope and with this change there can be a simple way to make the value propositions transparent in the marketplace for HVAC changes.

Harriman: There's currently something along these lines in California, communicating with the contractors about this.

Hammon: We used to do mechanical design in my company. We don't anymore because we used to right-size things, but then we go sued, so it's too expensive to keep doing this. We need to make consumers know that bigger is not better or else right-sizing won't happen.

Siddiqui: There's also the case if you've followed the topic of rebound—it's nothing new but it's gotten some momentum—involving criticisms that increasing energy efficiency will increase the propensity for over-sizing. It's an old argument in some cases and it's been refuted well in the past, but there's still a need to confront this from a lifecycle perspective and find a way to quantify this. In lieu of good information there are just contrary opinions.

Group A (Retrofit and New Construction Windows; Insulated Shades; Daylighting)

Ćurčija: We had to reorganize everything with our roadmaps because they didn't look very good. I'll start by mentioning what we came up with as far as R&D program titles go.

We have asked for the development of dynamic glazing systems, including improving the insulation value of glazing, which is still not close to adequate. Walls are getting up to R-19 and above, while windows are still hovering at R-3. Windows cannot be just insulating, but we also need some kind of dynamic controls for them as well. We have several research topics on this issue.

Another area is the retrofit of surface-applied films. Many products are available such as electrochromic films, or some of the low-energy products including passive dynamic films.

Another area is integration of glazing and photovoltaic (PV) to allow light to be transmitted and to use infrared spectrum to produce electricity. This is a challenging task. The majority of PV products produce electricity predominately in the visible spectrum, and this is a challenge.

Another of the areas identified would be angled skylights or vertical glazing, so advanced coatings that would minimize reflection that would be more scattering and absorbent to create electricity.

Insulating window frames: Frames make up about 20 percent of a window. Particularly in commercial buildings, where windows have to serve as structural members as well, they are often aluminum, so the thermal properties are not good—worse than glazing, in fact. So we need research to bring frames closer to residential windows in terms of insulation. One option includes gels that could be injected, or low-energy coatings for frames that reduces thermal energy transfer.

The next area was shading devices. We merged the roadmaps to get rid of clutter. The DOE is still debating if shading systems are part of fenestration systems, and recently they ruled that they were not. We should indicate this as part of the roadmap title.

We need to develop shading systems to control direct solar penetration and heat transfer. Could be interior or exterior technologies. We need to understand how these effect the window—high temperature influences the structure and causes premature failures. Also we need to understand how to design and integrate into the building envelope shades for control in different environments.

We call for a separate R&D program for different kinds of automation for different kinds of windows and shading systems. We need better algorithms for this and also for integrating these systems with the rest of the building.

We also need operable windows that included automated controls.

We need daylighting sensing for integrating with lighting controls. We need daylighting sensors to detect light levels to be able to communicate with the dynamic part of the glazing or shading.

We need performance assessment simulation and modeling, including developing models that can model all aspects of lighting and daylighting. Some models are worse than others, including the optical performance side, and how do we model in conjunction with whole systems? Also, what about ventilation in the models? We also need to harmonize modeling standards in conjunction with the work of the International Organization for Standardization (ISO)—there is a disconnect when Europeans or Japanese people use our windows because they don't recognize our standards, and vice-versa.

Field measurements are needed. When we measure such systems in buildings, we need an agreed-upon protocol for how to do this, also including ISO standards.

We need deeper penetration of daylighting into buildings and the integration of this with electric lighting.

We also have included aspects of human factors and labeling. Right now the random users of these products don't know what the labels mean—we need to measure for something like energy use per typical year, like refrigerators do, the label will indicate something like "each year this unit saves $25 of energy use." Industry resists this but we deserve better labels.

Human factors also includes comfort and glare, and how to express this in labels better.

We still need to finish some of the work we've done on this roadmap.

Harmon: Ddi you consider at all having a whole house with all inoperable windows by having other types of ventilation allowances? Wouldn't necessarily need to have operable windows if the ventilation was adequate and dynamic. This would allow more flexibility in energy efficiency.

Ćurčija: In our ventilation area we indicated that it could be a sash or through a device in the frame.

Harmon: We'll let the ventilation people address that—they could design systems that are more efficient. If we don't know what's coming in for non-operable windows, it's better to cut it out.

Anderson: We know that products have limited life spans. In the old days when a pane broke you just replaced it. Nowadays we have issues integrating window frames with moisture control systems. Should there be work on easily retrofittable window systems to replace the replacement process without having to disturb the frame?

Ćurčija: For the most part modern windows have sashes that you can replace, not the windows but the sash. We didn't even consider that kind of window replacement issue.

Ryan Fedie (BPA Energy Efficiency): I don't know if it came up around whatever gas is being used to insulate the windows, but is there an issue around the persistence of the gas, and transporting it across the country? Is research needed there?

Ćurčija: Glazing deflection, we don't have anything there. Glazing deflection is an issue at higher or low altitudes, or through the degradation of the gas. Some manufacturers put balloons around the windows to seal them for transportation. But over time the window can degrade, and that's something that could use some more research. Manufacturers don't like to admit that this occurs, but it does.

Werling: That is an excellent question, and let's expand it to everyone here. I heard discussion about tradeoffs between HVAC systems and enclosures. I think we have a very crude way of dealing with the relative values of systems, and this has to do with the cost effectiveness of the life of each measure, and there's a big difference between the life of an HVAC

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unit and the life of a building envelope. We have the ability to integrate some of this in our equations, but we don't have a way to integrate the risk of failure of these various systems. What's the risk of failure of a window, or an HVAC system, or insulation? If we knew this we could optimize our analysis of the life cycle. This applies to all technology areas.

Harmon: There is a real issue with being able to see through the window if it changes color ten years after installation or something, and then it needs to be fixed.

Werling: Research is the only way to understand risk component by component.

Ćurčija: We did some modeling around creating a selection tool for different attachments. We found that some shade systems can get up to 200 degrees [Fahrenheit] between the glazing and the shade. Manufacturers don't want to talk about this. We need to do research to find out if this is a problem or not in terms of the life of a window.

Lubliner: In terms of looking at early retirement, if we look at the residential retrofit market, one of the challenges in air sealing that we're looking at is back-drafting of water heaters so that we can better decide when to take out atmospheric-vented water heaters when we retrofit. What are the issues associated with back-drafting? Is it a big deal, or is the carbon monoxide exposure threat not that high? We don't have a common denominator for assessing risk in this area. The early retirement of water heaters would be a good data set to collect.

Roadmap Portfolio re-organization discussion

Binus: We hear a couple of main themes, both this week and during our August workshop. These are the need to have roadmaps that explicitly address integrated systems. We know that this is missing from the current portfolio and some time in the next six or twelve months we need to find a way to get integrated systems into this portfolio. Another major comment that we hear is that the current organizational structure does not discern important distinctions between residential, commercial, large commercial, and industrial sectors. What are some further thoughts on our current organization?

Pengilly: We'll, we just stuck with the organizational structure that we had.

Harriman: It was so clumsy to begin with that we couldn't do both—add to it and reorganize it.

Werling: At first when I saw this I scratched my head, but as I analyzed it further I realized that it's pretty close to the taxonomy we use at Building America, with a major exception and a comment to add. All these are components that we have, but you don't have a major category that we need, which is enclosure materials. This is because these are buried in the integration categories—which are "retrofit" and "new construction." It's probably good to keep these two separate in terms of the market. Would it make sense to make a new category for enclosure materials or assemblies, so that everything related to materials specifically goes into that column, and then these clearly become integrated into the retrofit and new construction columns? This it's a lot like the system we use.

Binus: Let's be sure to add this into the minutes. I can't remember what the term was that you used for this top level here.

Werling: It's a hybrid. The first two are about market delivery, and the rest are about technologies.

Harriman: Sub-systems.

Binus: Feedback anyone?

Harmon: I agree with Eric. If you look at manufactured housing, you need to look at components off-site. Manufactured homes includes components that also includes some of the materials that are included in the retrofit and new construction areas outside of the roadmap focused specifically on manufactured homes.

Desjarlais: We did what Eric said by default to some degree, and I agree with Eric.

Binus: So it sounds like we can start our reorganization based upon the changes the groups made to their roadmap posters and also from these comments.

Anderson: My thought on integration is that there is this phenomenon where there's a lack of responsibility for things that fall into the middle, between silos. One thing is to ask that each group takes responsibility for each area where the integration issues are in their group, and then they're assigned in the area as the process moves forward. For example, the windows group would be responsible for how the frames integrate with the envelope. They're responsible for finding the research topics. This would then lead to the integration of the research topics. Then you would have to make a decision for how you define these integration topics to the groups.

Binus: What if we had two sections, one for the residential/small commercial and the other for the large commercial/industrial sectors? Kind of like an octopus branching out, and where things overlap that becomes a catch-all, and the integrated roadmap to be created serves as a catch-all.

Harriman: I think he's talking about something different. Research should include integration within the larger system. Within the research project itself, we don't just have this new glass, but it has to go into the frame, and then into the wall. Integration must be a component of the research just as measure performance must be a component.

Binus: Maybe we should have teams looking at the portfolio to add integrated systems into where they need to be.

Jennings: Have a workshop specifically on integrated systems within the roadmaps.

Torcellini: As a starting point, can you take the opportunity to use the real estate on the page in terms of the rows, and at least have those things that align on the page do so because they are integrated systems and showing this with dotted-line boxes to identify these as primary integration areas. For example, if you're doing a retrofit of a window, and you're putting tinting in, have you considered how it impacts the lighting and the lighting controls, and this may make you think harder about if tinting is a good idea. The solution for one thing may have unintended consequences moving forward. Maybe the first step at doing this reorganization is lining-up these areas of overlap. You may want to consolidate things along the horizontal as well as the vertical, which is what we did today.

Binus: We can contact our colleague in the BPA Technology Innovation Office, Jisun Kim, to help us with this visualization.

Jennings: Maybe the re-organization will look more like a matrix?

Binus: Moving to the Internet will help make the organization more dynamic and intuitive in moving back and forth across all of these product and service areas.

Desjarlais: A topic that I think is missing is water management. We stuck it into the air sealing category, and it deserves a roadmap for itself. When we re-named this roadmap we were thinking in terms of managing both liquid and vapor, in and on the building.

Monk: I first looked at the roadmap priorities today for the first time. The work to date led me to wonder what context or strategy the group had in mind as it developed this - what it was thinking about. For example, at BC Hydro Power Smart, load reduction has been identified as job number one. You could have zero net energy home that has very low loads and is meeting these loads as efficiently as possible, or you could have a high-load zero net energy building that has a wide array of possible loads. I'm not sure if you all have a similar philosophy about what should be done first. The five areas we thought of are load reduction, energy efficiency, waste heat reduction, generating electricity with alternate sources, and generating thermal energy with alternative sources. What should the roadmap priorities be? Was this ever discussed?

Binus: The idea of overarching goals and priorities, or an overarching hierarchy of priorities . . . it's come up through the scoring prioritization that was done earlier. There was some different criteria that the Regional Emerging Technology Advisory Committee (RETAC) came up with. That prioritization is something that we yanked completely out of the roadmaps this year for a couple of reasons, primarily because they were not done entirely systematically in the first place and they were focused only on the gaps. The idea of the need for an overarching goal for the entire effort came up

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earlier this week, but we'll need a national or international steering committee to help us understanding overarching goals that have any applicability.

Fedie: Concerning the loading order for our drives, we all have different legislation at the state and regional levels that provides drivers for loading order for demand side activities. We have such a structure here in this region but only at a very high level.

Monk: I'm just not sure what your priorities are.

Fedie: Here in the Pacific Northwest our priorities are that conservation is to be looked at first, then other demand-side alternatives including waste heat recovery; next comes other sources of recovery, then on-site generation of renewables.

Monk: Yes, that's the kind of structure that I'm thinking of. Other things are beyond political considerations. For example, a low building load in Arizona could look very different from a low building load in Minnesota. It's more about climate that drives these roadmapping areas.

Harriman: I see this entire effort as not "national" at all, or if it is, it's only focused on electric energy efficiency. The title you're using isn't accurate at all. You should call it something like the "National Electric Site Efficiency Roadmap Portfolio."

Appendix A13:

Heating, Ventilation, and Air Conditioning Workshop (Sep. 27, 2012)

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September 24–27, 2012 | DoubleTree Hotel | Portland, Oregon

HVAC ROADMAPPING WORKSHOP

Thursday, September 27, 2012 | Adams / Jefferson Room, 1st Floor

Purpose

- Review/Confirm/Revise technology features and R&D programs for all residential and commercial roadmaps in the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio.*
- Prioritize (for deeper study) a sub-set of emerging technologies.

Facilitators: James V. Hillegas (BPA); Ellen Petrill (EPRI)

Support: Jennifer Williamson (BPA); Jack Zeiger (WSU EP)

8:00 am	Closing Plenary (Cascade Ballroom)
9:00 am	**Welcome and Introductions**
9:30 am	**Orientation:** Background, Description of Goals/Process
	Divide into Subgroups
10:00 am	**Review / Confirm / Revise Technology Features and R&D Programs**
	For every roadmap "thread," each subgroup will execute the following: **Task 1:** Review existing Drivers and Capability Gaps (revised on Aug. 8) **Task 2:** Review/Confirm/Revise Technology Features **Task 3:** Review/Confirm/Revise R&D Programs
12:00 am	Plated Lunch (delivered to room)
12:45 pm	**Continue subgroup tasks**
3:00 pm	**Subgroup Reporting & Group Discussions** (captured via verbatim minutes)
4:00 pm	**Next Steps:** ▪ R&D Program Prioritization ▪ Revisions to *Roadmap Portfolio* Organization Structure ▪ *Roadmap Portfolio* March 2013 draft
4:30 pm	**Emerging Technologies Prioritization**
5:00 pm	**Adjourn**

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National EE Tech Roadmapping Summit

DoubleTree Hotel, Portland, Oregon ~ Sep. 27, 2012

HVAC Roadmapping Workshop

Minutes of the sub-group reports – REVISED
2:45-4:15 p.m.

Group A (Motor-driven Systems; Heating & Cooling Production and Delivery)

1. Bruce Baccei (Sacramento Municipal Utility District)
2. Chris Bellshaw (Daikin (Americas) Inc.)
3. Ryan Fedie (Bonneville Power Administration)
4. Mark Firestone (PAE Consulting Engineers)
5. Jared Sheeks (MacDonald-Miller Facility Solutions, Inc)
6. Greg Towsley (Grundfos)
7. Xudong Wang (Air-Conditioning Heating, and Refrigeration Institute)

Group B (Heat Recovery & Economizer Optimization; Fault Detection and Predictive Maintenance)

8. Mark Cherniak (New Buildings Institute)
9. Jerine Ahmed (Southern California Edison)
10. Reid Hart (Pacific Northwest National Laboratory)
11. Kristin Heinemeier (University of California Davis, Western Cooling Efficiency Center)
12. Srinivas Katipamula (Pacific Northwest National Laboratory)
13. Phoebe Carner Warren (Seattle City Light)

Group C (Water Heating)

14. Amanda Ayoub (Portland Energy Conservation, Inc.)
15. Mike Lubliner (Washington State University Energy Program)
16. Graham Parker (Pacific Northwest National Laboratory)
17. Mark Rehley (Northwest Energy Efficiency Alliance)
18. Stephanie Vasquez (Bonneville Power Administration)

Group D (Residential HVAC Systems)

19. Dave Baylon (Ecotope Inc.)
20. Kyle Gluesenkamp (University of Maryland)
21. Todd Greenwell (Idaho Power Company)
22. Marshall Hunt (Pacific Gas & Electric Company)
23. Mark Johnson (Bonneville Power Administration)
24. John Karasaki (Portland General Electric)
25. Bruce Verhei (MountainLogic, Inc.)

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Group E (Commercial Integrated Systems)

26. Philip Haves (Lawrence Berkeley National Laboratory)
27. John Heller (Ecotope Inc.)
28. Richard Lord (Carrier Corp.)
29. Harvey Sachs (American Council for an Energy-Efficient Economy)
30. Pradeep Vitta (Southern Company)
31. Chris Wolgamott (Eugene Water & Electric Board)
32. Robert Wilkins (Danfoss)

Group F (Modeling, Lab, and Field Testing)

33. Ahmed Abdullah (San Diego Gas & Electric / Sempra Utilities)
34. Marc Brune (PAE Consulting Engineers)
35. Jack Callahan (Bonneville Power Administration)
36. Ron Domitrovic (Electric Power Research Institute)
37. Suzanne Frew (Snohomish County PUD)
38. Nicholas Long (National Renewable Energy Laboratory)

Minutes by James V. Hillegas (Bonneville Power Administration)

Group A (Motor-driven Systems; Heating & Cooling Production and Delivery)

Fedie: We didn't change the organization of our roadmaps. We felt our section of roadmaps were fairly broad, and that we had one of the few groupings of roadmaps that were broad. I'm going to start by covering the work we did on the motor-driven systems roadmap. We had a discussion around the efficiency in motors, how to reduce heat, and other issues, and also how to get more efficiency from motors at partial loads. The R&D around that was a drop in electronically commutated motors (ECMs), and understanding where we possibly can put ECMs in versus exclusive speed design (ESD) motors. We talked about what performance measures for ECMs we could use across the full range of speeds.

There was another thread of discussion around understanding where and how to install ECMs, the cost/benefits of this installation, and the market size.

Another topic of our discussion was the use and design of rare earth magnets in motors, including use of different materials, sizing, and configuration. [Harvey Sachs' post-Summit comment: "Just starting to learn about presumably non-rare-earth permanent magnet motors in consumer products, even garbage disposers. May give some energy benefits in low duty cycle motors w/o the huge costs of rare earths – and avoid a bunch of copper. Might be worth looking at."]

We have one R&D card up here on tools for selecting motor sizing and to see how the motor fits within the system, something like the design software tool MotorMaster.

Another subcategory that emerged in our team was around metering—how to get cheaper feedback regarding the subsystems including what do we have to do to redesign the electrical system and how to put in the meters so as to get cheaper feedback because it's costly today both to get meters installed and to collect and make use of the meter data.

We had an R&D card on the topic of getting more feedback from variable speed drives (VSDs)—partial loads, and annual performance data on how they're really working.

We also had a general discussion on the topic of how utilities prefer *real* data, as opposed to predictive data.

Anything else from the team to add on the topic of motors?

Sheeks: On the HVAC heating and cooling side, we had a number of R&D program ideas that were added and some that were already there about variable refrigerant flow (VRF) systems and mini-split systems, particularly about how these are best applied and controlled.

We had interesting things to discuss related to—on the production side—natural gas-driven heat pumps, and what the research on that would look like. We had some that were focused on codes and projecting what might be possible if things such as standard sequences of operation were built-in to the codes.

We had some discussion on the control side as well, such as self-optimizing controls like the "Hartman Loop" optimization system for industrial plants that might be able to be optimized for other applications.[1]

We had some discussions on economizers, a topic that crosses into the purview of other groups. In addition to the reliability of economizers, are there other sensing methods to be used to increase reliability?

Other than that there were some miscellaneous things such as solid state heating and cooling, and using any kind of liquids as refrigerants.

Oh, and there's Greg Towsley's idea about having a pump array configuration that could operate like a wall of fans. If we were to develop a wall of pumps, what kinds of efficiency could be gained from this?

Fedie: You also had one up there on standardized testing for refrigerants. Generally there was also a theme on separating ventilation air for space heating and cooling systems, and how best to develop these systems.

Wang: There is also one listed involving the testing of new refrigerants in terms of global warming. The Air-Conditioning, Heating, and Refrigeration Institute has an ongoing research program, Low-GWP Alternative Refrigerants Evaluation Program. The objective of the program is to identify and evaluate promising alternative refrigerants to the high-GWP refrigerants for major product categories. The program will not prioritize these candidates; rather will provide common sets of quality data for the industry to use. Thirty-eight alternative refrigerant candidates are being tested among residential and commercial products.

Vitta: Do you have any comparisons in your roadmaps between geothermal and variable refrigerant volume (VRV) systems, because they are cooling?

Sheeks: Yes we did. We filled out some R&D cards on this, such as efficiency gains of systems in comparison to VRF.

Cherniak: The Northwest Energy Efficiency Alliance funded a project with us at the New Buildings Institute in 2011 to analyze a brand new Trane rooftop unit (RTU). We had 50 percent savings on the supply fan, 30 percent on the ventilation fan, and an negative-9 percent result from the compressor.[2]

Sheeks: What was the total energy savings?

Cherniak: Well, the algorithms did not make it on the compressor side.

Bayon: I was not able to hear precisely what you said about the compressor and fan arrays, but it sounded like you were advocating installing incremental fans?

Sheeks: The idea was to install multiple smaller pumps to make up a complete system.

Baylon: Why would you do that instead of just installing variable speed drives?

Sheeks: There would be multiple variable speed driven pumps in the array.

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[1] For the Hartman Loop, see http://www.hartmanco.com/innovate/loop/index.htm.
[2] For a brief overview of this project, see Maggie Gulick, "NBI Puts High Performance HVAC Units to the Test," Aug. 21, 2012, http://newbuildings.org/blog/nbi-puts-high-performance-hvac-units-test.

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Baylon: Why do that?

Towsley: We have multiple systems that have demands upon them that vary significantly at different times of the day, yet the pump needs to be design to meet the peak, even if the peak is only a very small portion of the entire day. This means that we loose efficiency on the motor because it has to be over-built for most of the day so as to be able to meet the peak.

Baylon: Not if you install a variable speed drive.

Towsley: We've seen that sometimes the need for the pump could be 50 percent les than peak demands, so if you install and array of different-sized pumps you can meet the range of demand needed by turning the appropriately-sized pumps on and off, according to need.

Sheeks: Another of the benefits of existing fan arrays is that there are multiple small units that can be exchanged when one fan fails, rather than having to suffer down-time while the singular fan is replaced.

Domitrovic : Are there cost savings to building a pump array?

Sachs: There are times when it does make sense. One example is large multifamily housing retrofits that use a single water loop using a very small inexpensive cartridge pump to pull water out of the line and then push the water through the heat pump and back into the system. This is more efficient and does not require a valve, which is a major consideration for heat pump system designers.

Baylon: That's actually an embarrassing problem, because heat pump system losses are enough to wipe out any efficiency gains.

Vitta: Do you have in your roadmaps demand control thermostats in the commercial sector? There are some of these in the residential sector, but they are not yet available in the commercial sector.

Sheeks: One of our R&D cards did have that in there.

Ahmed: Did you discuss at all the fluid itself, either for heating or cooling?

Sheeks: We did not look at the liquids widely, but we did include some information on alternative refrigerants.

Ahmed: There are some phase change materials that might help with that.

Sachs: One research need that I'm sensitive to is that standards are based on simplified performance. What do we need to know about equipment to provide more effective specifications for systems?

Lord: There's a way of doing ducted systems where multiple units feed into the ductwork.

Group F (Modeling, Lab, and Field Testing)

Domitrovic : We had high-level discussions about the drivers, including why modeling was needed in the first place. These included market-based incentives, such as Leadership in Energy and Environmental Design (LEED) certification, as well as contractual obligations, so we added these to the structure of the drivers. Then we talked a bit about the twenty-year time horizon and what is the ultimate goal here. The concept was that in the process of designing a new building, the architectural design and the energy design would have to meld and live together; as the building is being constructed, the energy model would be adjusted. This may happen in twenty years or it may just be crazy.

We had some discussion about the need for additional data to validate and verify performance of systems for the sake of improving and validating the models.

Another thing we talked about was the distinct need for ease of modeling. There are two approaches to modeling. One is the sophisticated approach that says that the model does all that stakeholders request, but these models tend to be very complex and not necessarily user-friendly. The simpler and easier systems tend not to have the robustness to provide all of the answers that stakeholders seek. We need to find a balance between these two poles, and here is where research is needed.

A lot of our technology characteristics center on the need for new information on new technologies. How do these new systems behave, and how can this knowledge be integrated into new models? There is a need for a database with libraries of components and data on system behavior. We also need the ability to store very large amounts of data and have ready access to the data so that we can process it quickly.

In our research areas, for modeling in general, we focused on three areas. The saying is that you can get two of the three readily: good, fast, or cheap. We also need accuracy, so any research related to these areas is much needed.

Baccei: When you mention "fast," are you referring to the speed of the simulation time or of the labor involved in running the models?

Long: We were looking at a bit of both.

Domitrovic: A theme we also heard was that all of the variable speed systems are challenging to define for the models and to characterize their capabilities accurately in the models.

Long: Jack, we also have some R&D cards on the topic of field test data, do you want to go in to those?

Callahan: There are a couple of pieces to the field test data category. One that we focused on were RTUs. This was a whole testing in both the lab and the field. The focus of lab testing is to get better testing of RTUs. Instead of testing for qualifications, we need to test for performance maps that can address whole system performance and in-the-field performance. Some studies address parts of this issue but not all of it. For RTUs specifically, there is a need for testing as these systems come up across the whole range of expected operations, and to bundle this data so that modelers can use it.

Lord: That's what American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard Project Committee 205 (SPC 205) is working on right now.[3]

Callahan: We included that as a reference. Someone outside of the groups working on standards sees things differently from people trying to understand how equipment actually works in the field. There's a whole different set of drivers for both of these groups.

Baylon: A reasons there is a distinct problem is because we care how performance leads to the efficiency of the system and of the whole building. It's not obvious how existing systems relate to any of this.

Callahan: This issue could apply to RTUs and, really, any of these issues that we're talking about today.

Lord: The thermal capability is part of the ratings of the program.

Domitrovic: The ratings, especially equipment ratings, is really meant for equipment comparisons. Utilities need more information for energy use calculations in buildings. Maybe the ratings are useful in this way, maybe not. There is a need to fill in this area, and this is what Jack was addressing.

Lord: We need to change federal law. We have to include units at very low static [missed some of Dick's comment during this discussion].

Domitrovic: Even if the rating is there, you still need them for other applications.

Lord: The ratings used by the feds are really archaic.

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[3] See http://spc205.ashraepcs.org/.

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Baylon: You'd like to see the ratings where the higher-rated equipment is clearly differentiated from the lower-rated equipment.

Callahan: This next R&D program is to develop field monitoring and verification protocols to verify and validate new HVAC technologies that integrate zonal controls, both ducted and ductless systems. Targeting residential and small commercial applications. There is a need for research around zonal solutions and small solutions, mainly driven by new zonal systems.

Long: I'll add one more: validation of models. Standard 140 [ASHRAE Standard 140-2011] provides for a comparison of a model with other models, and doing so is a challenge when doing new things like VRF.[4] This R&D card is about restructuring what the standard looks like.

Baylon: In this region we have this requirement that the model results be calibrated with some kind of real data, and this can be taken as *prima facie* evidence that the model is not correct. That's about as much as we can do as utilities, otherwise we'd have to break apart the models and deal with them at the level of their algorithms.

Long: Maybe that's the way that Standard 140 may go, to validate the models with real data.

Callahan: Another thing we talked about was the verification of natural ventilation and performance. There are a lot of shortcomings in this area.

Another topic was field verification of variable air volume (VAV) fan operations, and research issues around central air systems and VRF systems, as well as application of zonal systems, particularly focusing on central air systems.

Lord: Did you consider thinking about an accuracy requirement? When you get in to Standard 140, the goal could be 10 or 15 percent accuracy, then there could be a standard program for modeling.

Long: We didn't put bounds on it like 10 or 15 percent, but we should add something about certification for modeling purposes.

Lubliner: Did you consider a round-robin of modelers—putting into a room five experts to help vet the models. The reason I bring this up is that we're working on guidelines with the National Institute of Standards and Technology (NIST) to convene these kinds of round-robins.

Ahmed: When you look at modeling, you're looking at the whole building. Is there any need for research on generation, ability usage, and storage, any research needs in that way?

Long: So, you're talking about grid interactions as well, interactions beyond the building?

Ahmed: Yes.

Long: No, we didn't include that here.

Ahmed: Even if you don't bring in the grid specifically, considering even site- or building-level generation, storage, etc., would be good points to consider.

Group C (Water Heating)

Rehley: Our scope around water heating was to focus on consumed water. We left off hot tubs, spas, swimming pools, and related systems. We covered a broad range of technologies involving both residential and commercial and both

[4] See "ANSI/ASHRAE Standard 140-2011, Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs," http://www.ashrae.org/standards-research--technology/standards--guidelines/titles-purposes-and-scopes#140.

electric- and gas-powered systems. One of the themes that came out was that the end user's experience drives much of what goes on: the end user wants hot water when they need it and at the location they need it and they don't want to wait for it. We covered where hot water was stored and how safe it was, including questions of potential vectors for disease if the water is stored somewhere.

We broke our technologies into a few sub systems to see how water was generated—was it by heat pump, solar power, etc. We asked, can we improve energy efficiency by collecting waste heat from all household and commercial sources? We looked at the relationships between water heating and demand response (DR), including protocols for DR. We called for research into test methods. We also analyzed segmentation into uses so that you can best match different solutions or combinations of solutions for those uses. I think we came up with some pretty good questions for our R&D cards.

Lubliner: We have a lot of them here. The first addresses the issue of point source—you want the thing that creates the hot water as close as possible to the end use. Achieving this could include micro heat pumps or nanotechnology solutions that delivers what the client desires while at the same time saving water and energy.

We talked a lot about solar hot water compared to heat pump water heaters (HPWH), and these compared to other strategies. How do they compare generally, but also across sectors, and within different types of buildings within a given sector? We were looking to find where we might have the best leverage.

There was some overlap in HPWH applications. If you take a HPWH and put them in McDonald's kitchens where there is a lot of waste heat, you have the potential for a lot of energy savings. Does it make sense to have a replicable program to do this kind of an application and for companies to be able to implement quickly?

We talked about intelligent water systems and smart fixtures that are looking at the trends. What kinds of temperature and flow rates do you need at the fixture itself?

Then we looked at gas absorption cycle heat pumps which have almost double the efficiencies. They're an emerging technology, and with a large market penetration of gas water heaters already, this technology is potentially very important.

Combination systems. Specifically establishing installation and commissioning guidelines for these systems. There are many of these systems in my area where people are doing instantaneous demand and radiant heat. What happens when you try to install many of these for people who are not familiar with combination systems? We need guidelines to help get this right.

Our next item was water heating testing protocols to compare things. A lot of time it is not always useful trying to model hot water systems in models—where is the water heater, what are the draw rates, and what type of water heating technology is in use? Is it a standard water heater or not? All of these elements are going to effect protocols.

The next item we talked about was back drafting and gas water heaters. We're spending effort at the Building Performance Institute (BPI) where we're tightening homes. What is the relationship between the atmospheric heater and the house? This is very important in the residential sector and there are plenty of research gaps there.

Water treatment to extend the life of emerging technologies. Some systems fail quickly because of bad water quality. There are also systems integration challenges here.

Manufactured housing is an issue. The majority of water heaters in U.S. Department of Housing and Urban Development (HUD) houses are electric. HUD doesn't recognize emerging technologies in their codes, so we can't consider more efficient systems. We're trying to change the HUD codes now to get tankless heaters approved for installation in these homes.

Finally, in regards to looking at moving the ducts into the conditioned space, we discussed how we need to move the water heaters into the conditioned rooms as well. There's more efficiency to be gained and also less chance of having frozen pipes. Therefore, there will be fewer insurance claims if the heating devices are inside the houses; it's just common sense.

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DR is also an issue that we looked at. The issue is that there is more information generally, and there's a need to get more of this information back to the user—utility or home owner—in a way that they can use it.

Lord: This is probably not on your list because you focused on domestic water heating, but there's a whole area of heating water in the space itself, and what temperatures do you want to heat it to. There are a lot of opportunities there as well.

Sachs: In terms of resources, you'lld find on the ACEEE website a 2012 report on emerging water heating technologies, policies, and practices and hot water forums.[5]

Vitta: Do you have as well heating and chilling systems—for example, in hospitals?

Lubliner: I didn't embellish much of what we wrote up in the area of heat recovery, but I included integration of systems to maximize water heating.

Rehley: We did also include a waste heat recovery section in our roadmapping here.

Lubliner: Our R&D program in this area is about a scoping effort to find out where the research areas are needed.

Lord: There is a project under 90.1 [ASHRAE Standard 90.1] that involves looking at the best way for energy recovery in water systems.[6]

Heller: Some work needs to be done in looking at HPWHs regarding which refrigerant you're using and how hot you can get the water, and when it makes sense to bring the water up to the level of an [R-]410A [refrigerant] unit to get water up to 105 degrees [Fahrenheit] and finish it with gas, as opposed to other systems.

Lubliner: This is a really good area for study. We tried a project with Bonneville Power Administration and were ready to go with it but we had a holdup with the leadership at Panasonic. CO2 refrigerants are compelling, even for space conditioning.

Lord: There's more work being done in this area in China and Europe than there is here.

Lubliner: The challenge that I've heard from NEEA's Jeff Haris is in looking at the standards for pressure safety and other things. How do you change the standards in these areas to integrate new technologies?

Baylon: John's point is not that CO2 is available, but that we know what the requirements are so that we can calibrate the system to produce the water temperatures that we need. The lesson here is not to throw-out the standard refrigerants just because CO2 is the next new cool thing.

Gluesenkamp: CO2 is really nice when you want to heat water all the way up, but not if you're trying to bring the temperature of warm water up the last few degrees.

Domitrovic : AT EPRI we've tested the first commercially integrated CO2 system, and these tested in the mid-threes for their efficiency factors. These are in use in Japan but not here yet.

Lord: In Europe they run it up to 156 degrees [Fahrenheit] because of a fear of legionella disease. (Harvey Sachs' post-Summit comment: "In the US, I believe that VT has a 140F requirement, but no one else does. OEMs seem much more concerned about scald than legionella for residential, and res. WH are shipped with 'stats in the 120F – 125F range – we're working on moving the test temp down from 135 to 120F. Not sure how you want to deal with this here ,but I could help."

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[5] Harvey Sachs, Jacob Talbot, Nate Kaufman, "Emerging Hot Water Technologies and Practices for Energy Efficiency as of 2011," ACEEE Report Number A112, Oct. 2011 (rev. Feb. 2012), http://www.aceee.org/research-report/a112.
[6] See "ANSI/ASHRAE/IES Standard 90.1–2010, Energy Standard for Buildings Except Low-Rise Residential Buildings," http://www.ashrae.org/resources--publications/bookstore/standard-90-1.

Group D (Residential HVAC Systems)

Baylon: We had the disadvantage and advantage of having nothing to start with. I'll provide the highlights of what we dealt with.

Health and indoor air quality (IAQ). There are two main issues here. Ventilation systems that can be efficient within the residential sector that are not overly costly. This is a much more serious issue in the residential sector with the increasing demand for heightened envelope standards.

The second area was lab and field testing, similar to what another group presented on. The point was how to go from testing to ensure that the results are also delivered in the field. This is a problem. Manufacturers shouldn't be guaranteed a certification or label for energy savings just because the equipment performed adequately during testing; if the equipment doesn't function adequately in real-world applications, this is functionally the same as not having a rating system at all. We should correct this.

There were several areas we covered that involved design. One of these was the use of integrated systems in design such as heating and hot water, and the different ways that this might happen with heat pump technologies or other kinds of combustion technologies, as well as the use of zonal systems with or without hot water. There's also the ever-popular need to communicate with our televisions.

Regarding contractors, we added the fact that the contractors not only need training but are integral to this process. This is particularly important in the residential sector, where energy efficiency depends crucially on the contractors not only knowing the specifications, but knowing *why* they need to abide by them. We need training and marketing support for these contractors. I'll bring to your attention the experience we had with ductless heat pumps (DHPs) in the Pacific Northwest: it was almost always the case that we first trained the contractors in this new technology, and got them onboard; we wanted to get them trained to know what they were talking about and also to deliver the system that we wanted.

On integrated DHPs and domestic hot water heaters (DHWs): We wrote down—especially for DHP-based systems—the need for systems that can include hot water in what would otherwise be another zone. We also brought up packaged internal units, through-the-wall units. These are ubiquitous because they are cheap, but in terms of energy efficiency they are horrible. However, with other technologies they might not be that horrible, and they may still be cheap. The goal is to develop them so that they are efficient *and* cheap, as opposed to merely cheap.

There's a lot to be said about heat recovery ventilation (HRV) units, particularly in the residential sector. In this space we have the oldest high-efficiency technology for residential applications, besides insulation. Some of the very first insulated houses in the early twentieth century still have good, working HRV units. We haven't developed this technology further. We need systems that both handle the IAQ issues and that deliver ventilation in a way that is at least integrated with the rest of the HVAC system.

On DR, we did have a conversation about DR and how much integration is needed with the utilities.

Karasaki: One of the key areas we looked at was cooling. We're looking at non vapor-compression cooling and ventilation systems. I was pushing systems where we can get ducts out of our lives, and where we can't do so we need to get ducts inside conditioned areas.

Baylon: I did have evaporative cooling down here, it is important in some areas of the Pacific Northwest, such as east of the Cascades. This technology is really of interest to those in California.

Domitrovic: Dave, what you said about Packaged Terminal Air Conditioners (PTACs), I think that your findings apply equally to window air conditioners.

Baylon: They are different in that a PTAC is installed as a permanent system, whereas window air conditioners are not.

Domitrovic: They are also more important in some parts of the country than in others.

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Baylon: Theres really isn't much that's energy efficient and cheap in terms of through-the-wall technologies.

Lord: What about existing homes, and how to get the old [Seasonal Energy Efficiency Ratio (SEER)] 7-, 8-, 9-rated units replaced?

Baylon: We didn't get too far into the area of retrofits. For the most part we did not address the legacy equipment out here, even though it's generally agreed that this is an important area.

Lubliner: My comment here regards [ASHRAE Standard] 62.2: both you and I are on that committee.[7] Did your group discuss the controls and optimizing the whole house in the residential sector, particularly as regards to 62.2 compliance in whole house ventilation retrofits?

Heller: There is a cross-over with water heating. We need work on design integration of HPWHs in residential applications to include understanding when it's best to exhaust hot air outside of the house and what the impacts of interactions are with the ventilation system. How do you install these in residential applications matters and depends upon what part of the country you are in, and it also matters how the house is built.

Vasquez: We wrote one along those lines as well, looking at homes and trying to collocate systems as close as possible, and asking if the systems could be designed OEM [original equipment manufacturer] like this. How expensive is it to make equipment like this, considering that they would require shorter runs of piping and wiring, etc.?

Callahan: This gets me thinking about a question: Looking way into the future, what do you see about radical new ways of thinking in terms of residential buildings and integrated HVAC systems? There's lots of discussion about how these kinds of buildings in the future will have significantly lower overall loads. If you have low loads like this, there are opportunities that arise that would not be possible otherwise. A good case argument here is with heat pumps integrated with hot water systems: You won't have this option available if the load is five tons for the house, but if the house load is only one ton, then the option is available.[8]

Gluesenkamp: Another item we discussed was separating sensible and latent cooling. We don't currently use reheat in residential air conditioning, but separating sensible and latent loads still has potential to increase comfort (by controlling humidity) while simultaneously reducing power consumption (by not overcooling when latent loads are small).

Wilkins: The long-term view of what residential systems will look like is a relevant question worth looking into. Some of the technologies we've been talking about are included in this, but it's also likely that the traditional refrigerants that we use today won't be around anymore in twenty or so years. If we're forced to use so-called natural refrigerants such as propane, do we really want to loop that around the living space? There's a lot of potential changes out there in front of us.

Baylon: I would argue that these problems become more tractable if you bring the load of the house down to one or two tons. If you don't do so, then you'll be talking about things like having a DHP head in each room. If you have propane lines in all of the appliances [missed the rest of this point]. Even if you're back to R-410A or some other refrigerant, it strikes us as a bad idea to build system designs around this issue.

Group E (Commercial Integrated Systems)

Sachs: Since we looked at integrated systems in commercial buildings, we decided to simplify the job and ignore the swim lane for Technology Characteristics. We jumped from the R&D programs directly to the Capability Gaps swim lane. I'll first sketch the drivers that we came up with.

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[7] See "ANSI/ASHRAE Standard 62.2-2010, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," http://openpub.realread.com/rrserver/browser?title=/ASHRAE_1/ashrae_62_2_2010_1024.

[8] 1 ton = 12,000 Btu/h or 3.516 kW.

Our drivers started with consumer demand for reduced, low-cost utilities. All of the reasons why a systems approach may make better sense in the transition to zero net energy and all of those things. Others included renewables on the grid, refrigerant changes, and market demand for "greenness." One of the issues we felt was really important was figuring out how to design systems for the workforces available and training for the workforces we'll need. Those were the big drivers we saw.

Our list of Capability Gaps includes: Education and training for how to work with systems; tools for working with the systems (including both hardware and software tools); linking design and operation to ensure accountability for energy performance—is what is coming out visible to the designers so that they can get some kind of feedback for them to incorporate into their latest designs? We also need operational support for building operators—also known as continuous commissioning; it's hard to get resources to sustain this approach. We also need investments in human resources for staff to support the entire life of the building. The building changes over the years, and how do we respond to this and get building controls and efficiency?

We need tools for integrated design and feedback on the results. We can't routinely define value to the utility—we can define kWh saved, and through DR we can track kW saved, but we're not very good at understanding the value of ancillary services. There is a fair amount of value for ancillary services. Related to this is the understanding and valuation of thermal storage, both hot and cold. Are we looking to kill peaks, or to kill loads? What are our goals for establishing relatively uniform analytical tools even if utilities in different areas have different needs?

Measurement and verification (M&V) occupant feedback system, dashboards, reporting—we're seeing a little of this in comparison to the previous day or year, but we need more.

There is a lack of benchmarking both in terms of design and operation—we don't have a clear understanding of the subtypes of buildings in specific areas.

There is a lack of valuation in the systems approach in utility and regulation programs. We are willing to pay bucks for energy efficiency ratio (EER) programs, but are we willing to pay big bucks for achievable savings for going to radiant floor technologies or other systems, as opposed to widgets? Until we understand and document the value of integrated systems, we'll not be aware of them and we'll eventually run out of technology widgets to install.

Another thing that is relevant for commercial buildings is quantification of non-energy benefits. We're trying to do utility programs that have incentives but we're not always sure what the proper incentives should be. For example, in my calculus of the total price for a Lexus, how can I account for the value of the consumer's desire to be seen as owning a Lexus? How much of this qualitative valuation translates into quantitative terms? There are some issues about how to quantify and value non-energy benefits that are important to the consumer.

Another I would mention is one that echoes things that other groups have said, and that is that federal standards—and even EnergyStar—are nowhere near broad enough to capture parameters and metrics for choosing system elements properly. We can't define a system by EnergyStar and other federal standards. We need to accelerate work that will give designers more information about systems without increasing the burden upon the designers.

Baylon: I'd like to re-emphasize Harvey's extensive rant: Benchmarking is critical. This is sort of the stepchild of energy efficiency evaluations. What we have not been able to do on a consistent basis—and this includes LEED and other utility programs and codes—is we can't ensure that we can use these techniques to deliver more efficient buildings. The average Energy Usage Intensity (EUI) I saw in 1988 was around 75,000 btus/square foot. The last time we looked, about three years ago, the number was the same. In the interim, we've got maybe three or four iterations of codes, untold millions of dollars spent in incentives, and we have labored mightily but we've produced a mouse. At this point, having a consistent benchmark, even if it's not perfect, would be better than if we kept arguing with the model, because the model won't deliver the savings.

Lord: Some studies have shown that we save energy in buildings and then we put more energy into buildings through plug loads, particularly consumer electronics.

Baylon: What we had in 1988 was a bunch of servers that were really inefficient. Yeah, we have a lot more computers, but they're a lot more efficient.

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Wilkins: I think this is a critically important topic. I'd like to make two points. One is to agree with others on the importance of benchmarking, so that you can differentiate building-to-building. Another is the need to get an effective building energy rating system so that it's transparent when the buildings meet or do not meet the ratings, and hopefully the value of energy efficiency is internalized and realized for both renters and sellers, so that energy efficiency gets translated into dollars and cents. It's critical to use market forces to do that. We listed a research project in this area. We need to take a look at other parts of the world and what works elsewhere and try to find best practices that we can replicate here.

Group B (Heat Recovery & Economizer Optimization; Fault Detection and Predictive Maintenance)

Hart: I'll start with just a brief overview of our drivers and capability gaps. Economizers: Will they ever work? Doing integrated control of RTUs that brings things together; heat recovery options and fault detection. We came up with a lot of technical stuff, but another key issue was training and human dimensions. I'll focus the rest of my time on the R&D cards that we revised or developed.

We crossed-off the heat recovery optimization routines R&D card entirely because that's already required technically, but it's still a workforce issue.

Natural ventilation—our card here is looking at optimizing this to reduce cooling loads.

Warren: The lower part of that card was me, we can come back to that.

Reid: There was something on LP [acronym meaning?] sensors stating that this matters in the Pacific Northwest; well, it also matters nationally.

Doing a premium ventilation testing in the Midwest.

Economic optimizer tools—there's work going on here.

One we rejected: Heat recovery grocery store refrigerators, and trying to modularize that. This seems like a common practice already.

Develop a works-for-sure economizer. Something totally foolproof. Maybe even getting away from the end result altogether.

There's a general question about investigating options for outside air recovery related to heat pumps. This needs work including in a retrofit situation—maybe a way to convert RTUs to common control.

Look in to fault response on compressors.

Optimization of preventative maintenance along with fault detection and diagnostics (FDD) and predictive maintenance.

A couple of these got merged: Taking the fault detection (FD) that we have now and simplifying it to something standalone on an RTU.

Local demand management—investigate a little further with the understanding that the whole thing wil be streamlined with DR needs.

Interoperability framework for retro commissioning. There are a couple of angles here. One is a toolkit to do monitoring at the building. Another is a standard protocol so that the trending analysis can be done quickly.

Adaptive controls for energy efficiency—advanced models based on adaptation.

Design of self-healing and correcting controls, some prior research identified.

RTU performance monitoring. There's a long list of R&D questions there.

Whole building optimal control driven by utility control to change buildings to be more grid responsive.

Behavior came up as well. We added Capability Gaps that we've seen with the workforce understanding of all these controls—how do we come to an understanding about how to get someone to respond to the alarms?

Low-cost wireless sensors to enable more data collection.

More workforce training.

Low cost control solutions for small and medium-sized buildings. This is the whole idea of taking direct digital control (DDC), which is sort of custom and sort of preconfigured, and creating something somewhat like an advanced programmable thermostat for the entire building.

Control usability to include testing protocols.

FDD for split systems and electromechanical systems.

Vertical integration of publicly-funded reference documents. How will these work together? Getting sequences available for broader standardization. Standards for FDD use.

FDD for evaporative cooling and pre-cooling technologies.

Field investigations to discover what faults are really out there and what do we really need to care about.

Lord: One thought here: It's too bad as an industry that we can't approach the development of common protocols like the auto industry has. This is where the standards come in and also the pull from utilities who can tell the manufacturers that they want a common protocol.

Sachs: Didn't that start in the auto industry with pushing by the Environmental Protection Agency (EPA)?

Lubliner: [Roy] Crawford made this same recommendation in working with the NIST on an industry standard—determining what it is that we need to know and approaching it from a common form. Once the auto industry did this, the costs decreased significantly. The suggestion here is not that this should be from the regulatory side, but that groups like the Consortium for Energy Efficiency (CEE) or other interested groups should be the one to spur this change. [Harvey Sachs' post-Summit comment: "This would have been Roy Crawford, University of Texas at Tyler,[9] formerly at Trane (where Jim Crawford also works) I'm quite sure of this from talking later with Roy, but you'll want to confirm."]

Sachs: The term "golden carrot" was mentioned. This is the kind of thing that the utilities can do by saying that they will pay for X or Y technology if the industry brings it to market. The utilities are in a better position to do this kind of thing in this area.

Baylon: To follow along with the FDD alarms point, it's fairly striking to me that someone mentioned yesterday that WalMart absorbs about 3,000 alarms per hour. With alarms at this frequency, it's the same as having no alarms.

Hart: Along with this research card is a call for alarm prioritization.

Lord: WalMart had a solution to that, and the solution was to take the alarm levels up a level. This was a Department of Energy initiative, but they eventually dropped it.

Cherniak: Dick, it was pushback from industry that knocked that down.

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[9] Roy R. Crawford, Ph.D., Director, Research & Technology Development, Texas Allergy, Indoor Environment, & Energy Institute (TxAIRE), University of Texas at Tyler, see http://www2.uttyler.edu/txaire/.

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Warren: It's related. It's not difficult to put together storage, or sensors; the limit is intelligence. What I'm hoping is that there will be provision for pooling intelligence and coming up with protocols. What's happening today is that the FDD will calculate the cost as it accumulates so that the response could be prioritized. Secondary benefits from this would be that the utility could support the process for cost savings. It won't work, however, unless it's transparent—we need to identify and calculate the cumulative costs. That's how we narrow the number of faults, we do so based on economics.

Baylon: Another possible strategy is that we have a bunch of auto metering going on, and we have these range checks to check alarms, and as we got better at using it the number of alarms went up, so that they became useless. Scaling them up and prioritizing them would be of great value.

Wilkins: One key thing to understand with WalMart is that the alarms that they had going on involved food quality as well as energy use, and that's where we saw thousands of alarms and realized the need to prioritize. We should be cautious about using supermarket alarms as a reference group for HVAC systems, the comparisons might not be all that direct.

Appendix A14:
Electronics Workshop (Sep. 27, 2012)

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ELECTRONICS ROADMAPPING WORKSHOP

Thursday, September 27, 2012 | Roosevelt Room, 1st Floor

Purpose

- Review/Confirm/Revise technology features and R&D programs for all residential and commercial roadmaps in the existing *Roadmap Portfolio*.
- Review and discuss proposed revision to the organizational structure of the *Roadmap Portfolio.*
- Prioritize (for deeper study) a sub-set of emerging technologies.

Facilitator: Joshua Binus (BPA)

Support: Ibrahim Iskin (PSU ETM); Rob Penney (WSU EP)

8:00 am	Closing Plenary (Cascade Ballroom)
9:00 am	**Welcome and Introductions**
9:30 am	**Orientation:** Background, Description of Goals/Process
	Divide into Subgroups
10:00 am	**Review / Confirm / Revise Technology Features and R&D Programs**
	For every roadmap "thread," each subgroup will execute the following: **Task 1:** Review existing Drivers and Capability Gaps (revised on Aug. 8) **Task 2:** Review/Confirm/Revise Technology Features **Task 3:** Review/Confirm/Revise R&D Programs
12:00 am	Plated Lunch (delivered to room)
12:45 pm	**Continue subgroup tasks**
3:00 pm	**Subgroup Reporting & Group Discussions** (captured via verbatim minutes)
4:00 pm	**Next Steps:** ▪ R&D Program Prioritization ▪ Revisions to *Roadmap Portfolio* Organization Structure ▪ *Roadmap Portfolio* March 2013 draft
4:30 pm	**Emerging Technologies Prioritization**
5:00 pm	**Adjourn**

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National EE Tech Roadmapping Summit

DoubleTree Hotel, Portland, Oregon ~ Sep. 27, 2012

Electronics Roadmapping Workshop

Minutes of the sub-group reports & discussion of the *Roadmap Portfolio* organizational structure – REVISED 2:45-4:15 p.m.

Group A (Component-level Efficiency; Complete Electronic Systems):

1. Brian Fortenbery Electric Power Research Institute (EPRI))
2. Yung-Hsiang Lu (Purdue University)
3. David Thompson (Avista Corporation)
4. My Ton (Collaborative Labeling and Appliance Standards Program (CLASP))

Group B (Use and Virtualization):

5. Ren Anderson (National Renewable Energy Laboratory (NREL))
6. Massoud Jourbachi (Northwest Power and Conservation Council)
7. Mukesh Khattar (Oracle Corporation)
8. Tony Lai (Delta Electronics)
9. Mark Monroe (Energetic Consulting)
10. Tom Reddoch (Electric Power Research Institute (EPRI))
11. Dennis Symanski (Electric Power Research Institute (EPRI))**

Group C (Interlock Devices to Manage Energy Use; Sleep Mode):

12. Lieko Earle (National Renewable Energy Laboratory (NREL))
13. Gary Hamer (BC Hydro)
14. Gregg Hardy (Ecova)
15. A.J. Howard (Energy Market Innovations (EMI))
16. Emily Kemper (Portland Energy Conservation, Inc. (PECI))
17. Bruce Nordman (Lawrence Berkeley National Laboratory (LBNL))
18. Danny Parker (University of Central Florida, Florida Solar Energy Center (FSEC))

Group D (Direct Current Power Source):

19. David Geary (StarLine DC Solutions (A Division of Universal Electric, Corporation))
20. Jim McMahon (Better Climate)
21. B.J. Sonnenberg (Emerson Network Power Energy Systems, USA)
22. Dennis Symanski (Electric Power Research Institute (EPRI))**
23. Paul Torcellini (National Renewable Energy Laboratory (NREL))

** Dennis Symanski was identified in the handwritten list as being in two groups.

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Use and Virtualization by Mark

- They pulled out a driver—it was a barrier. Added driver for data center cooling. Needed default opt-out for efficiency. Predict user demand. Temp and humidify both important to address in data center. More efficient server use; quantify capacity and utilization for servers to compare them. Cloud providers already do this well but won't discuss it much. They're not concerned with every type of device, just two sigma—those most common
- Optical fiber more EE than copper; how do they really compare? Is it worth the cost?
- People want any content, anytime, anywhere, any device.
- Programming techniques to shift more computing to centralized locations and load shift from a different data center with cheaper rates at that time and cooler climate (night)
- Prakesh
- You don't need to provide such cold water and air; warmer is okay, so use chillers with variable capability. Maybe use evaporative cooling.
- Make use of low-grade heat
- Mark
- Let devices communicate together more using open-source protocol—what each device should tell about itself
- Q&A
- Paul Torcelli: Do the current metrics adequately capture efficiency—PUI, etc. What does success look like? How much energy per e-mail, etc. Tomy Lai: There are different metrics for different user needs. Mark: They did discuss metrics a lot.
- Dennis Semanski: Virtualization had been around for a decade, but most data centers are at about 6%, some new ones at 15%. What's keeping that from improving? Prakesh: Data centers have to pay site license for virtualization software. Mark: Some cloud providers have solved this problem but won't talk about it—too competitive. Jeff Harris: There was talk of liquid coolers for servers, a better heat transfer medium. Prakesh: Yes, they should add high-density non-air cooling. Cost is usually the issue—lots of hoses. Jeff: So you need to solve how to integrate this into the architecture.

Component-level Efficiency by Brian

- They saw a driver they got rid of—the same one Mark killed. They mostly discussed the difference between components and systems. A system is a device that has a plug and holds components.
- Improve memory efficiency. Quatify the benefits of solid state operation (read/write versus spinning hard drive). Look at alternative memory technologies. Memoristers may be ten years out.
- Improve power supply efficiency. Expand beyond computer categories. Look at industrial power supplies. How efficient are they?
- Smart protocols. Distinguish between AC and DC inputs and new transistor types.
- Mitigate conducted and radiated emissions.
- Look at loss mechanisms to quantify standby losses, replace with alternatives. What's the cost and benefit of entering and leaving the stand-by state. Validate through demonstration.

System-level Efficiency by Brian

- Develop and demonstrate net-zero energy laptop by better components and wiring; vendors need to drive this. It won't require a power source. Maybe a PV panel built in or pizo-electric gets power from keyboard, or you shake it.
- Utilize components from mobile devices to better optimize power management and efficiency (i.e. Ecova's How Low Can you Go program).
- What components are needed for subsystems.

- X? ID technologies most susceptible to rebound effect. If you replace incandescent lamps with CFLs you may use them more since they so much more efficient. Why and how much do people do that? What's the impacts on HVAC? What are drivers for rebound and what can or should be done about it. Maybe it's okay. Get more security for pennies.
- AJ Howard. What might industry be working on and not talking about? Brian: Or they may talk about it but taking too long, so maybe an incentive could help accelerate their development process. Emerge helped accelerate DC power—now they have 100 members.
- Gary Hammer: The Lighting for Tomorrow has been going on it. Such challenges like NZE laptops can be effective in spurring industry development. Brian: In 2004 they made a challenge to innovate and they got many great innovations from that.

DC Power by Brian Patterson

- Eliminate transformation/conversion losses in both grids. There are more local grids and microgrids now. It's not just about efficiency—DC can also improve safety, simplicity, and reliability.
- Assess efficiency gains from applications of DC power by exploring measurements in DC and prioritize where to use DC. Couple with PV; DC is more natively compatible than AC. This could be broad applications or narrow—just used from some applications such as charging batteries.
- Get better and controlling power—how to communications—powerline carriers, wireless, or control wiring.
- Standardize connectors and adapters
- Monitor/meter power with utility-grade meters.
- Look into protecting equipment, controls, and safety issues—ground fault protect.
- Develop a DC building of the future that could improve people's understanding of DC

Q&A

- Brian heard the DC market will be $2 B in the near term.

Power Management, Control, and Communications by Bruce Nordman

- They covered everything electronic.
- They combined res/com, sleep modes and interlocking roadmaps into one; how devices can cooperate to save energy
- Are there better/cheaper ways for devices to communicate and networks
- Explore how people use devices. Set top boxes definitely need help, and do computer and other device sleep modes
- In some cases, EE is the main event, but in others EE a side benefit
- Gary Hammer: Getting devices to report out on their energy use, so we need standard communication protocols.
- Joshua: What were some of the most complex project?
- Bruce: If you want to ask a device about its energy use and what type of device it is, there needs to be a standard list of device types. There's an ASHRAE smart grid standard that had something like that but it dropped out there wasn't such a list. Bruce was part of another group, the IETF, that experienced the same outcome.
- AJ: Devices and people are so intertwined, which how they use the devices. The protocols need to allow people to use the devices as they want—for someone wanting to listen to a TV in another room, so the screen goes blank but the audio continues. AJ: These should requiring opting out to not have.
- Bruce: They also discussed centralized versus distributed control. Is it really useful to integrate these devices with an energy management system?
- Gary Hammer: Some customers resist having things turned off, but if you can show them that they won't be limited, they can warm up to it.
- Brian Patterson: Hospitals lose a lot of electronic equipment if the chain of custody has been broken—solving that issue may allow other use of energy efficiency communication features.

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- Prakesh: Energy efficiency by itself isn't enough—it has to also meet other business needs. It helps if efficiency features are the default; most people accept the default settings.
- Bruce: They also discussed temporary disabling of features such as computer management, so that after X hours it automatically reverts to normal settings.

Other Comments

- Brian Fortenbery: Did the DC group consider the universal transformer?
- Brian Patterson: They're hoping for a more efficiency conversion of high to low voltage—380 to 5V.
- Brian: We need to standardize and develop applications for DC because AC has 100 years of momentum for. Gary Hammer: How will the trades get trained on DC?
- BJ Sonnenberg: This is an opportunity to develop a global approach.
- Emily Kemper: What about the solar decathelon? Brian P: DC is horizontal, cutting across lighting, electric vehicles, etc. So it would be good so see a fully DC house. BJ: There are some of these around the world and even in the US.
- Gary Hammer: There's a huge proliferation of personal devices. We can't push back the wave but could try to convince people to recycle the devices
- Paul Torcellini: NREL saught a 50% reduction in plug loads, focusing on what's not being used, such as old fax machines and printers. Old refrigerator move to the basement. Dennis Symanski: Yes, when servers are virtualized to no load, they're still left plugged in. Bruce Nordman: The last day of the year in his office they try to clean up the place, and that could include unplugging everything and then in January plugging back in devices only as needed. Prakesh: Some machines are only needed quarterly, so sit idel for three months at a time. It's hard to know just what energy savings is for using the cloud and virtualization. Gary Hammer: If he gets cloud space for free, he'll use it, even for stuff he doesn't necessarily need backed up. Prakesh—Yes, the cloud is never turned off. Yung: Cloud providers consider a person's use so minor to not worry about it. BJ: But most people don't bother to consider the cost and energy use of data transmission. Bruce Nordman: Appliances and other devices could report their performance anonymously to some centralized place so that data on actual device performance could generate better policy. My Ton: That's a big issue for utilities—how are things actually being used? Gary Hammer: It's critical to ensure that anonymous input is truly anonymous. Danny Parker: It's hard to predict the proliferation of devices. We have 200 million set-top boxes now using 4,000 aMW—we didn't see that coming. Only now are they trying to improve them; that would have been great to address that at the get-go.
- Jim McMahon: He's discussed the rebound effect for 30 years. There's a lack of empiracle evidence. This has been used for economic arguments, used against the need for energy efficiency, so be careful of how the data may be misused.
- Jeff Harris: Yesterday a DC expert talked about developed a wall plug that provided by AC and DC power. Brian Patterson: He used AC neutral and an isolated ground to accomplish that. So technically this can be done, but there are issues of safety and keying to be addressed. A refrigerator can be made with AC and DC plugs. David Geary: One manufacturer is looking at a universal power supply. Brian P: He'll add that to roadmap. BJ: Improving device efficiency doesn't necessarily improve system efficiency. If power factor drops that causes more energy use. We need to look at systems wholistically.

Reorganization of Electronics Roadmaps

- Joshua: Maybe sensors/meter/EMS should be coupled with electronics; he's heard yes and no. Are we missing anything?
- Gary Hammer: He'd like to integrate silos. If devices report out their energy use, it should go to an EMS.
- Prakesh: We've focused on electronic devices, but not as electronics is used in lighting, HVAC, etc.
- Bruce Nordman: We're looking from the device-level up while EMS folks are looking from the top down. Emily: They could still be combined. David Geary: Electronics are becoming the catch-basket; maybe a two-dimenional roadmap. Brian Patterson: More cross-cutting is needed. Joshua: Each card could have a cross-cutting connection. Brian P: Maybe on the cards add a box for the name of PSA it relates to. Paul T: Electonics overlay on many boxes. BJ: It could be better, but the breakdown was quite good. He's never been at a better organized roadmapping workshop. XX: Prakesh: He suggests combining electronics and EMS, but then splitting up with hardware and intelligence—which could integrate with end use. AJ: He sees only about energy efficiency, not demand response. Joshua: He started out roadmapping with key stakeholders from the NW.

They wanted to keep demand response and smart grid aside because they could quickly swamp discussions on energy efficiency.

- Jim McMahon: A device doing service or doing work. We can focus efficiency on that. Then there's smartness and intelligence. The third element is communications, cross-system. Maybe communications is one of the subgroups.

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