

# APPENDICES

JULY 2010

# NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP



# Table of Contents\*

- Appendix A: Roadmapping Workshop Participation.....**
- Appendix B: Workshop 1 (Drivers, Products & Services, Goals).....**
  - Agenda .....
  - Focus Question 2 Output .....
  - Focus Question 3 Output .....
- Appendix C: Workshop 2 (Technologies and Gaps) .....**
  - Agenda .....
  - Workshop 2 Output .....
- Appendix D: Workshop 3 (Market Interventions, Programs, and Other Initiatives) .....**
  - Agenda .....
  - Workshop 3 Output .....
- Appendix E: Workshop 4 (Prioritization).....**
  - Agenda .....
  - Product/Service Area & Criteria Scoring Sheet.....
  - R&D Program Gap Scoring Sheet.....
  - Market Interventions/Programs/Other Initiative Scoring Sheet .....
  - Workshop 4 Output (Top 15 Products/Services Needing Wider Adoption).....

\* The original documents have all been hyperlinked to this table of contents. We have maintained the original pagination of each document.

# Appendix A: Roadmapping Workshop Participation



# Northwest Energy Efficiency Technology Roadmap: Workshop Participation

—December 2009 through February 2010—

## Workshop 1 (Drivers, Products/Services, Performance Goals)

1. Jack Callahan	Bonneville Power Administration
2. Todd Currier	WSU Extension 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 NW National Laboratory
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:* Leddbetter, Reddoch, Rehley
- *Sensors, Meters, and EMS:* Callahan, Currier, Holmes, Oliver

## Workshop 2 (Technologies and Gaps)

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	WSU Extension 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	PECI
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 NW National Laboratory
16. Pete Pengilly	Idaho Power
17. Rob Penney	WSU Extension 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	WSU Extension 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, EMS:* Smith, Oliver, Callahan, Livingood, Koran

## Workshop 3 (Market Interventions, Programs, and Other Initiatives)

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. Rem Husted	Puget Sound Energy
7. Mike Hoffman	Pacific NW National Laboratory
8. Gary Keyes	PCS UtiliData
9. Carol Lindstrom	Bonneville Power Administration
10. Jonathan Livingston	Livingston Energy Innovations
11. Laurence Orsini	PECI
12. Pete Pengilly	Idaho Power
13. Rob Penney	WSU Extension Energy Program
14. Tom Reddoch	Electric Power Research Institute
15. Mark Rehley	NW Energy Efficiency Alliance
16. James Thomas	Glumac
17. Kim Thompson	Bonneville Power Administration
18. Jeremy Wilson	PCS UtiliData
19. Jack Zeiger	WSU Extension 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)

1. Jack Callahan	Bonneville Power Administration
2. Todd Currier	WSU Extension 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

## Appendix B:

### Workshop 1 (Drivers, Products and Services, and Goals)



# 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

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 ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
<b>Building Design and Performance</b>				
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.
<b>Building Envelope</b>				
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

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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 <i>[placeholder for Fred Gordon suggestion to include Duct Ninjas - does he mean training protocols?]</i>	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
<b>Water Heating</b>				
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.
<b>HVAC</b>				
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

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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.
<b>Lighting</b>				
Solid state lights	In marketplace	◆◆◆◆◆◆◆◆	technical & market	Primary technical & market barriers are reflected in Hertz' 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. <i>OLEDs applied as paint-on products may be feasible in 10 to 20 years.</i>
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.

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
<b>Electronics</b>				
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 ( <i>also see direct/indirect evaporative cooler in HVAC section above</i> )	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			

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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.
<b>Regulatory</b>				
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.

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
 Products and Services, December 3-4, 2009

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.
<b>Appliances</b>				
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.

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

Technology Domain / Products & Services	Market Status	Roadmap Team Vote	Primary Barriers	Notes - including barrier details
<b>Other</b>				
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.
<b>EMS</b>				
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.

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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.
<b>Sensors and Meters</b>				
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

NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP  
Products and Services, December 3-4, 2009

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.
<b>Machine Drives</b>				
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"?
<b>Waste Energy Recovery and CHP</b>				
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	<ul style="list-style-type: none"> <li>• Awareness/training/technology</li> <li>• Easier methods to determine needs, financing, product development, codes and enforcement certification and branding</li> <li>• Non-utility weatherization funding</li> </ul>	<ul style="list-style-type: none"> <li>• 2015 – 5% of market 30% savings</li> <li>• 2020 – 10% of market 30% savings half those 50% or better</li> <li>• 2030 – 50% less energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>• Design &amp; analysis tools to integrate components and predict whole-system energy performance</li> </ul>
Labeling	<ul style="list-style-type: none"> <li>• Determine what it is</li> <li>• Get stakeholders to adopt</li> <li>• Develop national/regional stakeholder</li> <li>• Strong branding</li> </ul>	<ul style="list-style-type: none"> <li>• 2011 – consensus on labels</li> <li>• 2015 – 20% of homes meet standard</li> <li>• 2020 – mandatory</li> </ul>	<ul style="list-style-type: none"> <li>• Energy benchmarking tools</li> <li>• Data aggregation systems</li> </ul>
Retro and NC Windows	<ul style="list-style-type: none"> <li>• Lower cost/better technology</li> <li>• Design – education training</li> <li>• Code national/regional (day lighting) specs</li> <li>• Better labeling</li> <li>• Shift industry focus from residential to commercial performance standards – esp. superior frames and whole window performance</li> <li>• Concepts for next generation “same R-value as a wall” or ZNE windows</li> <li>• Electrochromic issues such as cost, life, performance</li> <li>• Address seamless PV integration into fenestration</li> </ul>	<ul style="list-style-type: none"> <li>• 2012 – increase window codes residential and commercial</li> <li>• 2015 – switchable window/PV 5% of replacement market</li> <li>• 2020 – residential envelope performance standards</li> <li>• 2030 – net energy producing 50% market</li> <li>• Skylights become alternative for lighting</li> </ul>	<ul style="list-style-type: none"> <li>• Next-gen coatings for triple-glazed IGs with superior SHGC and U-factor ratings</li> <li>• Integral low-E and PV windows</li> <li>• Self-powered electrochromic-PV windows</li> </ul>
Transformative Building Materials	<ul style="list-style-type: none"> <li>• Prefab components for low-cost ZNE construction</li> <li>• Make it easy for inexperienced workers to build right</li> <li>• Reduce carbon footprint of typical materials</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Modular, pre-insulated wall, floor, and ceiling units</li> </ul>
Solar/Smart Roofing	<ul style="list-style-type: none"> <li>• Technology/price/standards</li> <li>• Distribution/adoption</li> <li>• Local restrictions</li> <li>• Data/easy to install</li> </ul>	<ul style="list-style-type: none"> <li>• 2015 products readily available in marketplace at a low cost</li> <li>• 2020 – intelligent buildings with PV</li> <li>• 2030 – buildings codes that required solar</li> </ul>	<ul style="list-style-type: none"> <li>• Modular PV installation systems, including electronics</li> <li>• Cool / PV / DHW heater roofing</li> </ul>
Retrofit Insulation	<ul style="list-style-type: none"> <li>• Training/methods and technologies</li> <li>• Awareness – identification of need at a low cost, easier to install</li> <li>• <i>See IR scanning in NC section below</i></li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Insulation optimization via IR scanning &amp; analysis software</li> <li>• Community aerial IR scan + GPS data systems</li> </ul>

**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 – <i>should be in NC section below</i>	<ul style="list-style-type: none"> <li>• Better modeling/technology</li> <li>• Modular homes</li> <li>• Better materials with higher EE value</li> <li>• Easier to install</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Insulation optimization via IR scanning &amp; analysis software</li> <li>•</li> </ul>
Effective Insulated Shades	<ul style="list-style-type: none"> <li>• Better product/awareness</li> <li>• Aesthetically appealing</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• New materials for thin, super-insulating fabrics</li> <li>• Window-integrated insulating shades (built-in not added on)</li> <li>• PV-integrated window shades</li> </ul>

**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	<ul style="list-style-type: none"> <li>● Effective design</li> <li>● New technology</li> <li>● Education and training</li> <li>● Code change</li> <li>● Encouraging high density</li> <li>● Architect and engineers, installers, code/manufacturing</li> <li>● Branding urban areas and certification/commissioning</li> </ul>	<ul style="list-style-type: none"> <li>● 2015 – All new construction zero energy by 2030</li> <li>● 5% – 50% better than code</li> <li>● 2020 – 20% - 50% or better of that 50% are net zero after that code</li> </ul>	<ul style="list-style-type: none"> <li>● Design &amp; analysis tools to integrate components and predict whole-system energy performance</li> </ul>
Labeling	<ul style="list-style-type: none"> <li>● Determine what it is</li> <li>● Get stakeholders to adopt</li> <li>● Develop national/regional agenda</li> </ul>	<ul style="list-style-type: none"> <li>● 2011 – have labels</li> <li>● 2015 – 20% are using labels</li> <li>● 2020 – labeling mandatory increasing to meet zero energy</li> <li>● 2030 – Net zero label</li> </ul>	<ul style="list-style-type: none"> <li>● Energy benchmarking tools</li> <li>● Data aggregation systems</li> </ul>
Retro & NC Air Sealing	<ul style="list-style-type: none"> <li>● Data better/methods</li> <li>● Training improvements in identifying</li> </ul>	<ul style="list-style-type: none"> <li>●</li> </ul>	<ul style="list-style-type: none"> <li>● Next-gen substitute for blower door testing – cheap &amp; easy</li> </ul>
Eliminating Home Penetrations	<ul style="list-style-type: none"> <li>● Better designs</li> <li>● Codes/products/technology</li> <li>● Training</li> </ul>	<ul style="list-style-type: none"> <li>●</li> </ul>	<ul style="list-style-type: none"> <li>● Modular, pre-insulated wall, floor, and ceiling units</li> </ul>
IR Scanning	<ul style="list-style-type: none"> <li>● Lower cost/more awareness</li> <li>● Identifying need at a lower cost – part of labeling</li> <li>● Similar to car facts</li> </ul>	<ul style="list-style-type: none"> <li>● 2015 – cheap products widely available realtors/ contractors</li> <li>● 2020 – thermal overlay major meter areas</li> </ul>	<ul style="list-style-type: none"> <li>● Insulation optimization via IR scanning &amp; analysis software</li> <li>● Community aerial IR scan + GPS data systems</li> </ul>
Day Lighting Walls	<ul style="list-style-type: none"> <li>● Measurable</li> <li>● <i>Not sure what this means – refer back to proposer in Workshop 1</i></li> </ul>	<ul style="list-style-type: none"> <li>●</li> </ul>	<ul style="list-style-type: none"> <li>●</li> </ul>
Manufactured	<ul style="list-style-type: none"> <li>● Follow codes/code improvement</li> <li>● Retro structurally engineered</li> <li>● Panels that can easily installed – spray on</li> <li>● Elimination of duct work</li> </ul>	<ul style="list-style-type: none"> <li>●</li> </ul>	<ul style="list-style-type: none"> <li>● Modular, pre-insulated wall, floor, and ceiling units Modular, pre-insulated wall, floor, and ceiling units</li> </ul>

## 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	<ul style="list-style-type: none"> <li>Optimized design of lamp, ballast / driver, luminaire, controls for ease of installation, operation, maintenance</li> <li>Optimize use of fluorescent, SSL, halogen IR technologies by application</li> </ul>	<ul style="list-style-type: none"> <li>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))</li> </ul>	<ul style="list-style-type: none"> <li>Hybrid fluorescent / SSL technologies for optimum performance, cost &amp; aesthetics</li> </ul>
SSL	<ul style="list-style-type: none"> <li>Reduce cost</li> <li>Increase efficiency</li> <li>Improve stability over time</li> <li>Better CRI</li> <li>Better understanding by lighting professionals</li> <li>Improve lumen maintenance</li> </ul>	<ul style="list-style-type: none"> <li>200 lm/W for 3500 CCT (use DOE Roadmap #s) (50% of 180% goal) (L)</li> <li>Demonstrations</li> <li>Training/education</li> <li>Target early, cost-effective applications</li> </ul>	<ul style="list-style-type: none"> <li>Super-SSL – next generation L-prize winner meeting all needs identified in Gaps column</li> </ul>
Improve Task/Ambient Application	<ul style="list-style-type: none"> <li>Better user control of task lighting, including user-moveable luminaires</li> <li>Ability to have task lighting quantifiable reduce overall light levels and lighting energy consumption</li> </ul>	<ul style="list-style-type: none"> <li>(15% of 80% goals) Establish as standard practice: reduced ambient light levels coupled with increased use of task lighting (L)</li> <li>Codes</li> <li>Training/education</li> </ul>	<ul style="list-style-type: none"> <li>User-aware controls that reduce ambient levels for task and energy optimization</li> </ul>
Lighting Controls (Dimming, OC Sensors)	<ul style="list-style-type: none"> <li>Cheaper controls</li> <li>More reliable controls</li> <li>Training and education</li> <li>Better human interface</li> </ul>	<ul style="list-style-type: none"> <li>50% reduction (25% of 80% goal) (L)</li> </ul>	<ul style="list-style-type: none"> <li>Improved sensing technology to make controls more natural for users (poss. military-derived)</li> </ul>
More Efficient Luminaires	<ul style="list-style-type: none"> <li>Market needs to be rewarded for efficient luminaires</li> <li>Change common metrics from source efficacy to luminaire efficacy</li> <li>Use FTE <i>[what is this?]</i> for outdoor lighting</li> </ul>	<ul style="list-style-type: none"> <li>In residential sector, begin shifting emphasis from efficient sources, to efficient luminaires</li> </ul>	<ul style="list-style-type: none"> <li>Metrics for light delivered, task and aesthetic performance, not light emitted</li> </ul>
Day Lighting	<ul style="list-style-type: none"> <li>More responsive controls, esp. for</li> </ul>	<ul style="list-style-type: none"> <li></li> </ul>	<ul style="list-style-type: none"> <li>Next gen ambient</li> </ul>

	<ul style="list-style-type: none"> <li>• Easier to design, commission and operate</li> <li>• Better light quality as perceived by users</li> </ul>		controls
--	--	--	----------

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	<ul style="list-style-type: none"> <li>• Retain intelligence</li> <li>• Capability to restore to full functionality</li> <li>• Responsive to user needs and preferences</li> <li>• Minimal user interaction required</li> </ul>	<ul style="list-style-type: none"> <li>• Require sleep mode features that reduce energy usage by 90% (S-M)</li> <li>• Work with manufacturing community as in trade associations and interest groups</li> </ul>	<ul style="list-style-type: none"> <li>• User –sensing and user-aware controls</li> <li>• Sleep-mode chip or equivalent design standard</li> </ul>
DC Power Source	<ul style="list-style-type: none"> <li>• Lack of DC network infrastructure</li> <li>• Access to DC powered end use</li> <li>• Evidence that DC has predictable energy savings benefits compared to AC, and under what conditions</li> </ul>	<ul style="list-style-type: none"> <li>• Develop access to DC power sources to simplify AC/DC conversions and reduce losses (M-L)</li> <li>• Work with state/local entities to invoke codes and standards</li> </ul>	<ul style="list-style-type: none"> <li>• Standard DC system products for voltage conversion, facility level distribution and device connection</li> </ul>
Use and Virtualization	<ul style="list-style-type: none"> <li>• Standard calculation methods to predict savings</li> <li>• Standard approaches to maintain reliability and performance with reduced energy use</li> </ul>	<ul style="list-style-type: none"> <li>• Create advanced internal (to the device) energy management systems (virtualization) to reduce energy usage (M)</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>
Component Level Efficiency	<ul style="list-style-type: none"> <li>• Disclosure by component and system manufacturers of how interactive effects increase or cancel out energy savings</li> </ul>	<ul style="list-style-type: none"> <li>• Development of low loss components for electric devices (example: substitute LED lighting for fluorescent back light in LCD TV) (M)</li> </ul>	<ul style="list-style-type: none"> <li>• Tools for modeling component interactive energy impacts</li> </ul>
Complete Electronic System	<ul style="list-style-type: none"> <li>• Needs an interface to the smart grid feature</li> <li>• Turn off all home electronics w/o disrupting functionality – smart strip equivalent software or chip that can be built into any product</li> <li>• Make saving energy without sacrificing user experience a CEO goal</li> </ul>	<ul style="list-style-type: none"> <li>• Reduction of 50% in energy usage based on today's performance (M)</li> </ul>	<ul style="list-style-type: none"> <li>• Benchmark high-performance (energy and user experience) products in each category – e.g., TVs, video games, DVRs, etc.</li> </ul>
Interlock Devices to Manage Energy Use	<ul style="list-style-type: none"> <li>• Convenient not inconvenient for users</li> <li>• Designed in, not added on to systems</li> </ul>	<ul style="list-style-type: none"> <li>• Develop low cost systems that permit “quick” adoption (S)</li> <li>• Provide incentives to help bring devices to market</li> </ul>	<ul style="list-style-type: none"> <li>• Standard interlock systems &amp; components available to OEMs for their products</li> </ul>

**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
<p>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</p>	<ul style="list-style-type: none"> <li>• Trained technicians (hopefully not needed as much)</li> <li>• Don't currently have "on-board" diagnostics or data streams to collect</li> <li>• Don't have redundant or corrective hardware</li> <li>• Not tied to building needs/loads</li> <li>• Doesn't communicate (2-way) well with building controls relative to performance issues in equipment and systems</li> <li>• Don't currently optimize use of ambient or indoor conditions, e.g., economizer, indoor ventilation controls, heat recovery</li> <li>• Current high-energy use for distribution of heat and cooling beyond actual vent need</li> </ul>	<ul style="list-style-type: none"> <li>• 100% of new construction self-diagnosing controls for the packaged HVAC unit (S)</li> <li>• Predictive maintenance in 100% of new sales (S)</li> <li>• Economizer controls &amp; systems (seals, actuators, dampers) that are reliable &amp; effective (S)</li> <li>• Functional performance test definition for factory testing (S)</li> <li>• Variable speed control on ALL systems, fans, compressors, pumps, etc. (S)</li> <li>• Ventilation/temperature/humidity delivery matched to actual uses at granular level so controls can be designed appropriately with monitoring (M)</li> <li>• Intelligent controls connected/communicating with buildings &amp; spaces so unit delivers only what spaces need (M)</li> <li>• Predictive controls to optimize operation (M)</li> <li>• Initial self-healing/correcting (M)</li> <li>• Pattern recognition/learning system (M)</li> <li>• Non-vapor compression cooling (S.S. or Evaporative) (L)</li> <li>• Packaged equipment (up to 20 tons capacity) for 100% of new construction, to capture all lost opportunities in the new and replacement market (L)</li> <li>• Controls to meet indoor air needs – no excess vented air beyond occupant needs (L)</li> <li>• Delivery of only what the space of occupant needs (L)</li> <li>• Intelligent Systems with predictive, diagnostic controls &amp; self-healing processes (L)</li> <li>• Maximum efficient distribution of HVAC (don't use ducts if you don't need them) (L)</li> <li>• Work with manufacturing community as in trade associations and interest groups</li> </ul>	<ul style="list-style-type: none"> <li>• User-aware &amp; self-diagnosing controls for the packaged HVAC unit</li> <li>• Predictive maintenance</li> <li>• Reliable &amp; effective economizers controls &amp; systems</li> <li>• Variable speed everything with low cost, high reliability</li> <li>• Fast, accurate controls for enthalpy and air flow</li> <li>• Wireless controls that meet or exceed all standards for wired controls</li> <li>• Hybrid vapor compression / evap cooling systems and sub-systems</li> <li>• Desiccant cooling (if shown to be more viable than in the past)</li> </ul>

**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	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Cost to add-on sensors is high (e.g., install an occupancy sensor for a light fixture)</li> <li>• Central EMS control is expensive and often not responsive to users</li> <li>• “Dumb” devices are not much fun.</li> <li>• Need low-cost control capabilities</li> <li>• Standardization of protocols</li> <li>• Sufficient intelligence somewhere in the system to manage conflicting inputs</li> </ul>	<ul style="list-style-type: none"> <li>• Occupancy sensor controls available in common devices (see gaps) (S)</li> <li>• Standards for electronic devices (S)</li> <li>• Extension of smart controls to lighting and HVAC (M)</li> <li>• 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)</li> <li>• Modular generic control/sensor packages are available at low cost (10% of device cost or less) (L)</li> <li>• Modular generic control sensor package responding to occupancy temperature light level, air quality, and user input (L)</li> <li>• User input is standard, cheap, and ubiquitous (e.g., by cell phone, standard IR controller, voice command, or similar) (L)</li> </ul>	<ul style="list-style-type: none"> <li>• Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input</li> </ul>
Easy/simple user interface controls	<ul style="list-style-type: none"> <li>• Based on manufacturer design</li> <li>• Does not consider demographic operability</li> <li>• Make user experience as important to EMS manufacturers as it is to Intuit and Sony</li> </ul>	<ul style="list-style-type: none"> <li>• Survey consumer needs (S)</li> <li>• Support demonstration projects (M)</li> <li>• Create standards (L)</li> <li>• Interfaces need to allow for different levels of sophistication of users (L)</li> <li>• Controls need to connect to large number of devices/features to allow users to address amenity control needs (L)</li> <li>• Control management system should be implemented where appropriate, reflect user/occupant known preferences (L)</li> <li>• 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)</li> </ul>	<ul style="list-style-type: none"> <li>• Industry-wide user experience test standards and minimum performance requirements</li> </ul>

**ENERGY EFFICIENCY PERFORMANCE GOALS**  
**SENSORS, METERS, ENERGY MANAGEMENT SYSTEMS**

<b>Energy Efficiency Product &amp; Service Area</b>	<b>Gaps/Needs</b>	<b>Performance Goals – Short (S), Medium (M), Long (L) Term</b>	<b>Gap-filling technologies</b>
Consumer Energy Management Services	<p>Residential:</p> <ul style="list-style-type: none"> <li>• Homeowners do not have expertise to manage energy</li> <li>• Very small marginal savings available</li> <li>• Rates are changing and hard to understand</li> <li>• Homeowners need to control energy costs and be able to respond to higher rates and changing rate standards</li> </ul> <p>Commercial:</p> <ul style="list-style-type: none"> <li>• Lack of energy management expertise</li> <li>• Single sites have small marginal savings</li> </ul>	<ul style="list-style-type: none"> <li>• Bundle energy management services for cost effectiveness (S-M)</li> </ul>	<ul style="list-style-type: none"> <li>• Cheap, standardized, user-aware, modular control sensor packages responding to occupancy temperature light level, air quality, and user input</li> </ul>
Low-Cost Savings Verification Techniques	<ul style="list-style-type: none"> <li>• Need to be able to attribute energy performance improvements and affects to actions/widgets to: <ul style="list-style-type: none"> <li>- Value and measure impacts of our investments (utilities, states)</li> <li>- Provide consumers with information/feedback on energy affecting decisions</li> </ul> </li> <li>• Devices for measuring widget performance are currently relatively expensive add-ons that are expensive to retrieve information from.</li> </ul>	<ul style="list-style-type: none"> <li>• Low-cost savings verification techniques (L)</li> </ul>	<ul style="list-style-type: none"> <li>• Savings verification monitoring, data collection and transmittal devices on a chip that costs pennies and can be incorporated into any product</li> </ul>
Real-time Smart Electric Power Measurement of Facilities	<ul style="list-style-type: none"> <li>• No standard technology</li> <li>• Retrofit is expensive</li> <li>• Devices lack intelligence</li> <li>• Results can be complicated</li> <li>• Consumer are not motivated</li> </ul>	<ul style="list-style-type: none"> <li>• All utility customers have networked smart meter in 8 years (S-M)</li> <li>• Create standards (M)</li> <li>• Numerous appliances and devices have embedded and networked power meters (M)</li> <li>• Legislate compliance (L)</li> <li>• All electric end-uses over 1 kW have embedded and networked power metering in 15 years (L)</li> </ul>	<ul style="list-style-type: none"> <li>• Data collection, analysis, and customer feedback systems to optimize whole-system energy performance</li> </ul>

# Appendix C:

## Workshop 2 (Technologies and Gaps)



# 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**

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

## Deep Retrofits for Residential & Commercial

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. 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)		GOAL (GL)	
	GL1. 5% of market 30% savings (ST)		GL2. 10% of market 30% savings (MT)	
Technology (TC)	TC1. Self-programmable Smart Thermostats			
	TC2. Technology exists, need to apply it at an acceptable cost for homeowners		TC5. Existing building commissioning tools •Building screening tools •Energy savings and estimates (CA Pier Project)	
	TC3. District heat planning, sharing			
	TC4. Mixed use: use heat from commercial for residential, integrate markets		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.	

## Labeling

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. Determine what it is	GP2. Get stakeholders to adopt	GP3. Develop national/regional stakeholder	GP4. Strong branding	
	GOAL (GL)		GOAL (GL)		
	GL1. Consensus on labels (ST)		GL2. 20% of homes meet standard (MT)	GL3. Mandatory (LT)	
	Technology (TC)		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				

## Retro and NC Windows

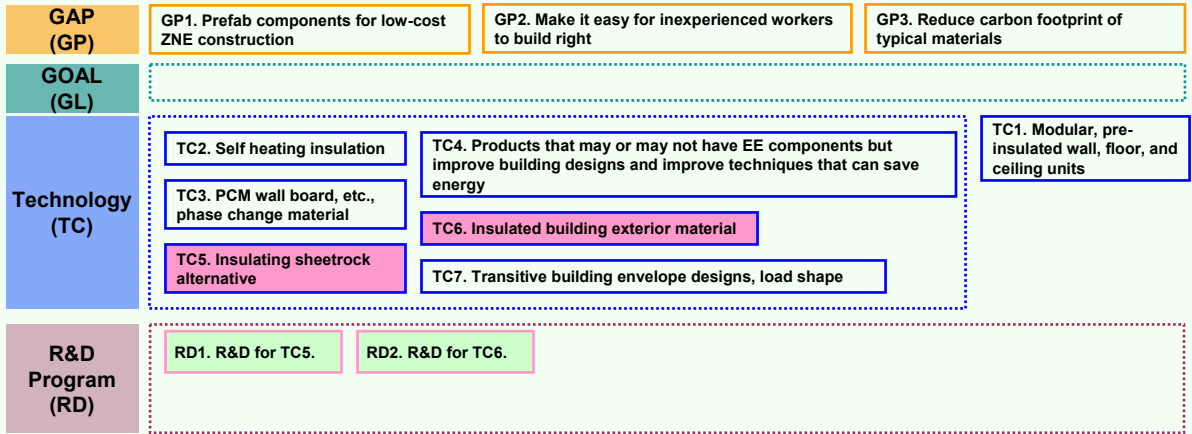
TC	Technology Gap (R&D need)
RD	R&D Gap (No known R&D)
RD	Current R&D (R&D underway)
	Comment

GAP (GP)	GP1. 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)		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.

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

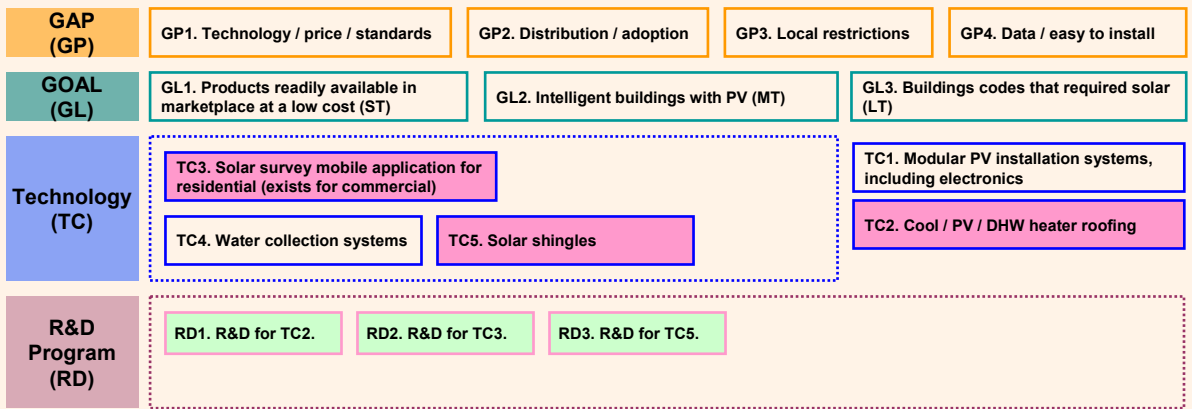
## Transformative Building Materials

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



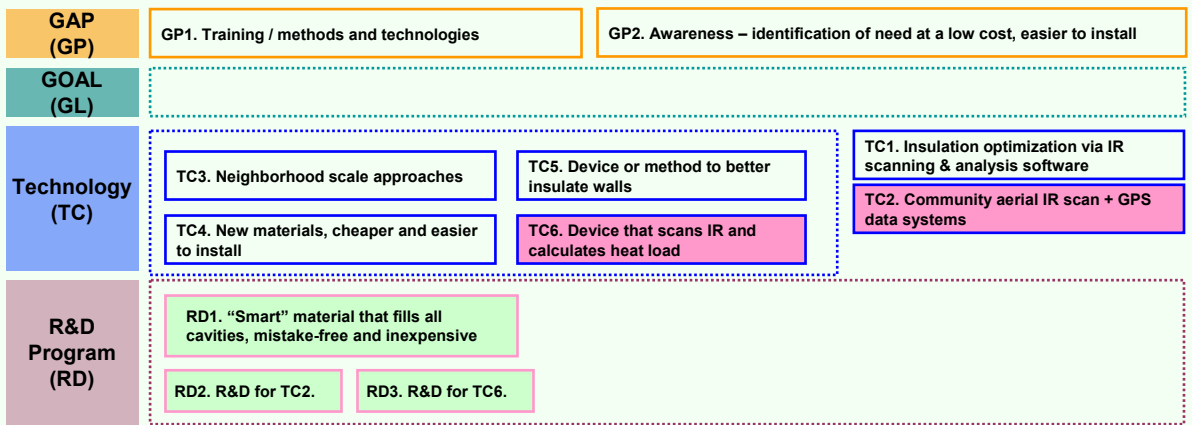
## Solar / Smart Roofing

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



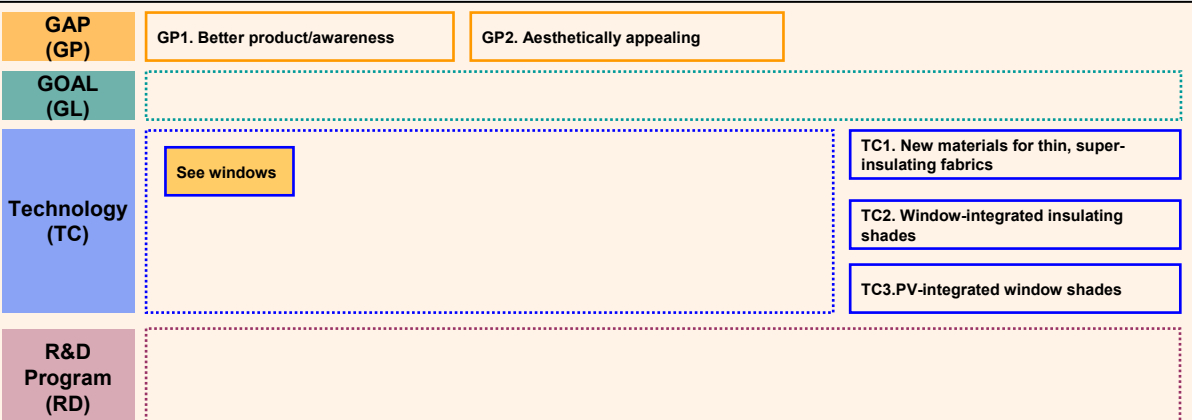
## Retrofit Insulation

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

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

<b>Net Zero Energy Home</b>	<b>GAP (GP)</b>	GP1. Effective design	GP2. New technology	GP3. Education and training	GP4. Code change	GP5. Encouraging high density	GP6. Architect and engineers, installers, code/manufacturing
	<b>GOAL (GL)</b>	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)	GP7. Branding urban areas and certification / commissioning		
	<b>Technology (TC)</b>	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					
	<b>R&amp;D Program (RD)</b>	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.

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

<b>Labeling</b>	<b>GAP (GP)</b>	GP1. Determine what it is	GP2. Get stakeholders to adopt	GP3. Develop national/regional stakeholder			
	<b>GOAL (GL)</b>	GL1. have labels (ST)	GL2. 20% are using labels (ST)	GL3. labeling mandatory increasing to meet zero energy (MT)	GL4. Net zero label (LT)		
	<b>Technology (TC)</b>	TC3. Faster/cheaper approaches	TC4. Uniform MLS Requirement	TC5. Valuation of label	TC6. Access to utility billing data	TC1. Energy benchmarking tools	TC2. Data aggregation systems
	<b>R&amp;D Program (RD)</b>	RD1. (Exists) Cal Arch, Energy I2 Action, Ecotype tool		RD2. Energy information systems – numerous existing (see LBNL reports)			

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

<b>Retro &amp; NC Air Sealing</b>	<b>GAP (GP)</b>	GP1. Data better/methods	GP2. Training improvements in identifying
	<b>GOAL (GL)</b>		
	<b>Technology (TC)</b>	TC2. Checklists (test effectiveness)	TC1. Next-gen substitute for blower door testing – cheap & easy
	<b>R&amp;D Program (RD)</b>	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

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

<b>New Construction Insulation</b>	<b>GAP (GP)</b>	GP1. Better modeling / technology	GP2. Modular homes	GP3. Better materials with higher EE value	GP4. Easier to install
	<b>GOAL (GL)</b>				
	<b>Technology (TC)</b>	TC2. Foam/siding attachment	TC3. Insulating structural panels	TC1. Insulation optimization via IR scanning & analysis software	
	<b>R&amp;D Program (RD)</b>	RD1. Application technology, “easy and cheap”			

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) 2/2

<b>Eliminating Home Penetrations</b>	<b>GAP (GP)</b>	GP1. Better designs	GP2. Codes/products/technology	GP3. Training
	<b>GOAL (GL)</b>			
	<b>Technology (TC)</b>	TC2. Surface mount electrical	TC4. Products unrelated to energy savings but eliminate wall penetrations	TC1. Modular, pre-insulated wall, floor, and ceiling units
	<b>R&amp;D Program (RD)</b>	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	
<b>TC</b> Technology Gap (R&D need) <b>RD</b> R&D Gap (No known R&D) <b>RD</b> Current R&D (R&D underway) <b>Comment</b>		Most technologies are already exist.		

<b>Day Lighting Walls</b>	<b>GAP (GP)</b>	GP1. Measurable		
	<b>GOAL (GL)</b>	GL1. Design cost/complexity	GL2. Better design support tools	
	<b>Technology (TC)</b>	TC1. Easier, cheaper daylight modeling tools that give energy benefits	TC2. Devices for deeper penetration of light into spaces, i.e.: light shelf	TC3. Retrofittable exterior window shades
	<b>R&amp;D Program (RD)</b>	RD1. Devices for deeper penetration into space @ UBC, LBNL	RD2. R&D for TC1.	
<b>TC</b> Technology Gap (R&D need) <b>RD</b> R&D Gap (No known R&D) <b>RD</b> Current R&D (R&D underway) <b>Comment</b>				

<b>Manufactured</b>	<b>GAP (GP)</b>	GP1. Follow codes/code improvement	GP2. Retro structurally engineered	GP3. Panels that can easily installed – spray on	GP4. Elimination of duct work
	<b>GOAL (GL)</b>				
	<b>Technology (TC)</b>	TC2. Automated/robotic assembly	TC1. Modular, pre-insulated wall, floor, and ceiling units Modular, pre-insulated wall, floor, and ceiling units		
	<b>R&amp;D Program (RD)</b>	RD1. Shop floor innovative technologies similar to auto industry			
<b>TC</b> Technology Gap (R&D need) <b>RD</b> R&D Gap (No known R&D) <b>RD</b> Current R&D (R&D underway) <b>Comment</b>					

<b>IR Scanning</b>	<b>GAP (GP)</b>	GP1. Lower cost/more awareness	GP2. Identifying need at a lower cost – part of labeling	GP3. Similar to car facts
	<b>GOAL (GL)</b>	GL1. Cheap products widely available realtors/ contractors (ST)	GL2. Thermal overlay major meter areas (MT)	
	<b>Technology (TC)</b>	TC3. IR Smart phone	TC5. Aerial photos to target	TC1. Insulation optimization via IR scanning & analysis software
	<b>R&amp;D Program (RD)</b>	TC4. Google street view w/ IR	TC2. Community aerial IR scan + GPS data systems	
<b>TC</b> Technology Gap (R&D need) <b>RD</b> R&D Gap (No known R&D) <b>RD</b> Current R&D (R&D underway) <b>Comment</b>		RD1. Marry the energy technology with smart phone/device technology		

<b>Lighting</b>	<b>GAP (GP)</b>	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
	<b>GOAL (GL)</b>	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))	
	<b>Technology (TC)</b>	TC1. Hybrid fluorescent / SSL technologies for optimum performance, cost & aesthetics	TC2. Luminaire optics for plasma light
	<b>R&amp;D Program (RD)</b>	RD1. Lighting productivity research @ LRC, Hescong Mahone	RD2. Study health impacts of lighting @ LRC, others
		RD4. Red LED integrated into CFL for improved CRI	RD5. R&D for TC2.
		RD3. Self-cleaning luminaires	RD5. R&D for TC2.

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>SSL</b>	<b>GAP (GP)</b>	GP1. Reduce cost	GP2. Increase efficiency	GP3. Improve stability over time	GP4. Better CRI	
	<b>GOAL (GL)</b>	GP5. Better understanding by lighting professionals	GP6. Improve lumen maintenance	GL1. Demonstrations	GL2. Training/education	
	<b>GOAL (GL)</b>	GL3. Target early, cost-effective applications	GL4. 200 lm/W for 3500 CCT (50% of 80% goal) (LT)	TC1. Super-SSL – next generation L-prize winner meeting all needs identified in Gaps column		
	<b>Technology (TC)</b>	TC2. Manufacturing methods	TC3. Fixture design for many different applications that use			
<b>Technology (TC)</b>	TC4. Tiny lights	RD1. Electric system compatibility				
<b>R&amp;D Program (RD)</b>	RD2. Substrate growth improvements @ DOE contractors					RD3. SSL life extension @ Philips, Cree, 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	

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>Improve Task/ Ambient Application</b>	<b>GAP (GP)</b>	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	
	<b>GOAL (GL)</b>	GL1. Codes	GL2. Training/education	
	<b>GOAL (GL)</b>	GL3. (15% of 80% goals) Establish as standard practice: reduced ambient light levels coupled with increased use of task lighting (LT)	TC1. User-aware controls that reduce ambient levels for task and energy optimization	
	<b>Technology (TC)</b>	TC3. Avoid "cave effect"		
<b>Technology (TC)</b>	RD1. Human factor- usability and comfort			
<b>R&amp;D Program (RD)</b>				

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>Lighting Controls (Dimming, OC Sensors)</b>	<b>GAP (GP)</b>	GP1. Cheaper controls	GP2. More reliable controls	GP3. Training and education	GP4. Better human interface	
	<b>GOAL (GL)</b>	GL1. 50% reduction (25% of 80% goal) (LT)				
	<b>Technology (TC)</b>	TC1. Improved sensing technology to make controls more natural for users (poss. military-derived)				
	<b>R&amp;D Program (RD)</b>	<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 2px;">TC1. Sensors don't light empty spaces</div> <div style="border: 1px solid black; padding: 2px;">TC3. Adjust lighting levels to time of day</div> <div style="border: 1px solid black; padding: 2px;">TC5. Easy to change setting on sensors</div> <div style="border: 1px solid black; padding: 2px;">TC7. Cheaper, more simple self calibration</div> </div> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div style="border: 1px solid black; padding: 2px;">TC2. Link to HVAC and Plug Load Controls</div> <div style="border: 1px solid black; padding: 2px;">TC4. Better location of occupancy of sensors</div> <div style="border: 1px solid black; padding: 2px;">TC6. Sensors that do not turn off when occupied</div> <div style="border: 1px solid black; padding: 2px;">TC8. Building-wide user fixtures</div> </div>				

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>More Efficient Luminaries</b>	<b>GAP (GP)</b>	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	
	<b>GOAL (GL)</b>	GL1. In residential sector, begin shifting emphasis from efficient sources, to efficient luminaires			
	<b>Technology (TC)</b>	TC1. Metrics for light delivered, task and aesthetic performance, not light emitted			
	<b>R&amp;D Program (RD)</b>	<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 2px;">TC2. Ballast for CFL with low on/off penalty</div> <div style="border: 1px solid black; padding: 2px;">TC3. Higher lumen watt stick forecast</div> </div>			

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>Day Lighting</b>	<b>GAP (GP)</b>	GP1. More responsive controls, esp. for horizontal day lighting	GP2. Easier to design, commission and operate	GP3. Better light quality as perceived by users	
	<b>GOAL (GL)</b>				
	<b>Technology (TC)</b>	TC1. Next gen ambient and task lighting sensors and controls			
	<b>R&amp;D Program (RD)</b>	<div style="display: flex; justify-content: space-between;"> <div style="border: 1px solid black; padding: 2px;">TC2. Cheaper and more simple self calibrating dimming controls</div> <div style="border: 1px solid black; padding: 2px;">TC4. Skylight design</div> </div> <div style="display: flex; justify-content: space-between; margin-top: 5px;"> <div style="border: 1px solid black; padding: 2px;">TC3. Core day lighting system</div> <div style="border: 1px solid black; padding: 2px;">TC5. Day lighting sensors</div> </div>			

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

## Sleep Mode

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

<b>GAP (GP)</b>	GP1. Retain intelligence	GP2. Capability to restore to full functionality	GP3. Responsive to user needs and preferences	GP4. Minimal user interaction required
<b>GOAL (GL)</b>	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	
<b>Technology (TC)</b>	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	
<b>R&amp;D Program (RD)</b>	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.		

## DC Power Source

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

<b>GAP (GP)</b>	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		
<b>GOAL (GL)</b>	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		
<b>Technology (TC)</b>	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”		
<b>R&amp;D Program (RD)</b>	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

## Use and Virtualization

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

<b>GAP (GP)</b>	GP1. Standard calculation methods to predict savings	GP2. Standard approaches to maintain reliability and performance with reduced energy use				
<b>GOAL (GL)</b>	GL1. Create advanced internal (to the device) energy management systems (virtualization) to reduce energy usage (M)					
<b>Technology (TC)</b>						
<b>R&amp;D Program (RD)</b>	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 for energy savings
	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/web energy usage same as RD1.

<b>Component Level Efficiency</b>	<b>GAP (GP)</b>	GP1. Disclosure by component and system manufacturers of how interactive effects increase or cancel out energy savings			
	<b>GOAL (GL)</b>	GL1. Development of low loss components for electric devices (example: substitute LED lighting for fluorescent back light in LDCD TW) (MT)			
	<b>Technology (TC)</b>	TC2. Optoelectronics/ Photonics			TC1. Tools for modeling component interactive energy impacts
	<b>R&amp;D Program (RD)</b>	RD1. Integrated solutions for device component on/off state	RD3. Power supply efficiency @ PIER	RD5. Chip efficiency @ AMD, Intel	RD7. More simple and more energy efficient PCs that still meet needs of 70% of users @ Dell, HP, Apple?
		RD2. Broad research on component level efficiency opportunities in electronics	RD4. Memory efficiency @ SanDisk, others	More awareness of energy of plug-ins	

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>Complete Electronic System</b>	<b>GAP (GP)</b>	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			
	<b>GOAL (GL)</b>	GP3. Make saving energy without sacrificing user experience a CEO goal				
	<b>Technology (TC)</b>	GL1. Reduction of 50% in energy usage based on today's performance (MT)				
	<b>R&amp;D Program (RD)</b>	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
		RD1. Integrated design @ mfgs.	RD3. Integrate algorithms with device architecture @ NetApps, others			
		RD2. Broad research on system – level efficiency opportunities in electronics	RD4. Rebound effect – which technologies are most susceptible? -@ behavior, M&V specialists			

**TC** Technology Gap (R&D need)

**RD** R&D Gap (No known R&D)

**RD** Current R&D (R&D underway)

**Comment**

<b>Interlock Devices to Manage Energy Use</b>	<b>GAP (GP)</b>	GP1. Convenient not inconvenient for users	GP2. Designed in, not added on to systems		
	<b>GOAL (GL)</b>	GL1. Develop low cost systems that permit "quick" adoption (ST)	GL2. Provide incentives to help bring devices to market		
	<b>Technology (TC)</b>	TC1. Standard interlock systems & components available to OEMs for their products			
	<b>R&amp;D Program (RD)</b>	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	

**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: 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 <sub>2</sub> 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. Geoechange with HRV (may be abandoned)
TC19. HPWH, heat recovery for whole house heating	TC20. Retrofit variable air flow system wireless,	TC21. Retrofittable 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 testing 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 information about energy use, improving controls	
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 easier	
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	

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 1/3**

## Smart device – level controls responsive to user and environment

<b>GAP (GP)</b>	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
<b>GOAL (GL)</b>	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		
<b>Technology (TC)</b>	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"	
	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 (?)		RD3. To what degree are these simply autonomous agents?
<b>R&amp;D Program (RD)</b>			

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

<b>GAP (GP)</b>	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	
	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)
<b>GOAL (GL)</b>	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)			
<b>Technology (TC)</b>	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			
<b>R&amp;D Program (RD)</b>	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	

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**

<b>Consumer Energy Management Services</b>	<b>GAP (GP)</b>	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)										
	<b>GOAL (GL)</b>	GL1. Bundle energy management services for cost effectiveness (ST-MT)										
	<b>Technology (TC)</b>	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 3 <sup>rd</sup> 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										
	<b>R&amp;D Program (RD)</b>	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.								
		<table border="1" style="font-size: small;"> <tr> <td style="background-color: #e91e63; color: white;">TC</td> <td>Technology Gap (R&amp;D need)</td> </tr> <tr> <td style="background-color: #c8e6c9;">RD</td> <td>R&amp;D Gap (No known R&amp;D)</td> </tr> <tr> <td style="background-color: #ffe0b2;">RD</td> <td>Current R&amp;D (R&amp;D underway)</td> </tr> <tr> <td style="background-color: #ffcdd2;">Comment</td> <td>Comment</td> </tr> </table>			TC	Technology Gap (R&D need)	RD	R&D Gap (No known R&D)	RD	Current R&D (R&D underway)	Comment	Comment
TC	Technology Gap (R&D need)											
RD	R&D Gap (No known R&D)											
RD	Current R&D (R&D underway)											
Comment	Comment											

<b>Low-Cost Savings Verification Techniques</b>	<b>GAP (GP)</b>	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								
	<b>GOAL (GL)</b>	GL1. Low-cost savings verification techniques (LT)										
	<b>Technology (TC)</b>	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							
	<b>R&amp;D Program (RD)</b>	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?									
		<table border="1" style="font-size: small;"> <tr> <td style="background-color: #e91e63; color: white;">TC</td> <td>Technology Gap (R&amp;D need)</td> </tr> <tr> <td style="background-color: #c8e6c9;">RD</td> <td>R&amp;D Gap (No known R&amp;D)</td> </tr> <tr> <td style="background-color: #ffe0b2;">RD</td> <td>Current R&amp;D (R&amp;D underway)</td> </tr> <tr> <td style="background-color: #ffcdd2;">Comment</td> <td>Comment</td> </tr> </table>			TC	Technology Gap (R&D need)	RD	R&D Gap (No known R&D)	RD	Current R&D (R&D underway)	Comment	Comment
TC	Technology Gap (R&D need)											
RD	R&D Gap (No known R&D)											
RD	Current R&D (R&D underway)											
Comment	Comment											

# 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 D:

## Workshop 3 (Market Interventions, Programs, Other Initiatives)



# 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

**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
<b>Building Design and Performance</b>					
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
<b>Building Envelope</b>					
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

**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
<b>AARA groups</b>					
4	◆	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	◆	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	◆	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		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		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 & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives	
<b>Water Heating</b>						
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? Volvet Price Target high C/I users Solar ready construction?

**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 & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives	
<b>HVAC</b>						
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: refig 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.

**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 & Service 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?

**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 & Service 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

**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 & Service 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

**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
<b>Lighting</b>						
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 Retention 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 (residential) 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]
<b>Appliances</b>						
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

**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
<b>Electronics</b>						
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	

**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
<b>Electronics (Continued)</b>						
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"

**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
<b>Electronics (Continued)</b>						
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 Association, which has taken a hard line in California and w/Energy Star - try a "détente" model?

**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
<b>Electronics (Continued)</b>					
	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					

**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
<b>EMS</b>						
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 proposition 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 proposition 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

**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
<b>Sensors and Meters</b>					
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 proposition 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

**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
<b>Sensors and Meters (continued)</b>					
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?

**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 (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

**Other (Industrial, Agricultural, etc.), Machine Drive, and Waste Energy Recovery/CHP**

Existing Product & Service Domain	Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
<b>Other (Industrial, Agricultural, etc.)</b>					
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 critical
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/commissioning	Installation verification Issue of how to evaluate "appropriate for use" Feedback --> vendor performance program

**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 & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
<b>Machine Drives</b>						
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 critical
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 <del>power movers</del> 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 & Service Domain		Roadmap Team Vote	Primary Barriers	Description of the Barriers	Existing Programs and Initiatives	Core Components of Future Programs and Initiatives
<b>Waste Energy Recovery and CHP</b>						
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)

**NORTHWEST ENERGY EFFICIENCY TECHNOLOGY ROADMAP WORKSHOP III**

Market Intervention Programs and Other Initiatives for the Existing Products and Services

Regulation

Existing Product & Service 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.		

# Appendix E:

## Workshop 4 (Prioritization)



# 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 Scoring of R&D program gaps

to  
1:00 pm

#### 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 Scoring of Available Products/Services

to  
4:00 pm

#### 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

# 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	

# 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	

# Prioritizing the Criteria

<b>Criteria of R&amp;D programs</b>	<b>Score (1-5)</b>
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	

<b>Criteria of Products not widely adopted</b>	<b>Score (1-5)</b>
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	

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				

**Product & Service Area: A2. BUILDING DESIGN/ENVELOPE FOR NEW CONSTRUCTION (NC)**

<b>Product &amp; Service Group</b>	<b>R&amp;D Program</b>	<b>C1: Potential energy efficiency savings for NW</b>	<b>C2: Potential non-energy benefits / consumer value</b>	<b>C3: Ability of NW to contribute to the development</b>	<b>C4: Research focus uniquely applicable to NW</b>
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				

**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				

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"				

**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					

**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?				

**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				

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					

**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.				

**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				

<b>Lighting</b>					
<b>Product &amp; Service Area: A3. Lighting, Appliances, and Electronics</b>					
<b>Product &amp; Service Group</b>	<b>Core Component of Future Programs and Initiatives</b>	<b>C1: Potential energy efficiency savings for NW</b>	<b>C2: Potential non-energy benefits / consumer value</b>	<b>C3: Ability of NW to affect market</b>	<b>C4: Readiness of widespread adoption</b>
Solid state lights	Incentives for street lights/deemed savings Avoid bad products/black eye Signage on grocery LEDs Consumer incentives to offset cost (residential) 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				

<b>Appliances</b>					
<b>Product &amp; Service Area: A3. Lighting, Appliances, and Electronics</b>					
<b>Product &amp; Service Group</b>	<b>Core Component of Future Programs and Initiatives</b>	<b>C1: Potential energy efficiency savings for NW</b>	<b>C2: Potential non-energy benefits / consumer value</b>	<b>C3: Ability of NW to affect market</b>	<b>C4: Readiness of widespread adoption</b>
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				

**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				

**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				

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				

**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				

**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)				

<b>EMS</b>					
<b>Product &amp; Service Area: A5. Sensors, Meters, and Energy Management Systems</b>					
<b>Product &amp; Service Group</b>	<b>Core Component of Future Programs and Initiatives</b>	<b>C1: Potential energy efficiency savings for NW</b>	<b>C2: Potential non-energy benefits / consumer value</b>	<b>C3: Ability of NW to affect market</b>	<b>C4: Readiness of widespread adoption</b>
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 proposition 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 proposition 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				

**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 proposition 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				

**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 proposition 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?				

# High Priority Products / Services Needing Wider Adoption

High Priority  
Core Component of  
Future Programs and Initiatives

Product & Service  
Area

Building Design,  
Performance, and Envelope

Water Heating and HVAC

Lighting, Appliances, and Electronics

Driver

**Market Driver:** 1. Proliferation of consumer electronics; 2. Globalization of Manufacturing; 3. Changes in transportation energy systems; 4. Cost & Price w/ Best Buy, Comcast

**Behavior / Social Driver:** 1. Consumer desire to be "green"

**Regulatory Driver:** 1. NW Council's \$0 to \$100 per ton carbon penalty; 2. Increasing focus on codes and standards (DR ready); 3. Utility rate designs

**Cost Driver:** 1. Uncertainty about fuel price, availability, reliability

**Technology Breakthrough Driver:** 1. More mobility of people electronically, digitizing info, social networking; 2. Diffusion of "Smart" capability into all energy consuming devices

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.

Environmental interlocks – hotel key locks

Power conversion

Efficient home electronics

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

Wireless homes

Solid state lights

Smart strips – turn off appliances when not being used

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

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.

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 market pull by clients', industry, and government agencies' requirement to achieve broad acceptance.

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.

Design/availability of user-friendly modeling tools; Formal education programs (colleges); Cross-disciplinary education at the right time - use professional associations 75

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

Application guidance Supply chain strategy Training 87

Explanation field test 78

(Not defined) 96

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

(Not defined) 74

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

(Not defined) 73

X-Box = 200W = 3/4 Fridge WILL = 20 watts 76

Core Component

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

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 100

Incentives for street lights/deemed savings; Avoid bad products/black eye; Signage on grocery LEDs; Consumer incentives to offset cost (residential) 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

Driver

Market Barrier for Adopting a product & Service

Product and Service

Core Component of Future Programs and Initiatives

#

Priority Score of Market Programs and Initiatives (Max=100)