B O N N E V I L L E P O W E R A D M I N I S T R A T I O N

Analysis of Next Generation Nonresidential Energy Codes in the Northwest

A Report to the Bonneville Power Administration

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Executive Summary

The goals of this project were to 1) evaluate the potential energy savings and costs from the next generation of regional nonresidential energy codes as well as 2) compare these codes to the current Bonneville Power Administration (BPA) new construction offerings. This report summarizes the findings and analysis.

The next-generation energy codes in BPA's territory are the 2012 International Energy Conservation Code (IECC) in Idaho, Montana, and Washington and the Oregon Reach code in Oregon. These codes will be the basis for the next round of mandatory energy codes in the region, though certain states may delay adoption, not adopt, or may adopt with modifications. If adopted, the codes will impact conservation programs by raising base efficiency levels, and prior to adoption could themselves be candidates for early code adoption program measures.

This study includes findings on energy savings from next-generation codes; projected floor area of new construction in BPA's territory; and BPA's nonresidential program offerings. Key findings are presented below.

Forecasted Next-Generation Energy Code Potential Savings

Our analysis found that the Oregon Reach code with the lighting option would result in a 7.7% decrease in electric use over current Oregon Energy code; in Idaho and Montana, the 2012 IECC with the lighting option would result in an 8.9% decrease in electric use over the 2009 IECC, and in Washington the 2012 IECC with the lighting option would lead to a 1.5% decrease in electric use over the 2009 Washington State Energy Code. The total potential savings—if all new construction in BPA territory were to build to the next-generation code and comply with the lighting option—is 0.7 aMW annually. Electric savings and cost are summarized in Table 1.

Washington State, where most of the new construction activity in BPA's service territory is expected to occur, does not have a clear next-generation code. Washington is moving to the 2012 IECC, which is roughly comparable to the current 2009 Washington State Energy Code (WSEC). Deliberations have begun for the 2012 WSEC, and early proposed revisions look to increase energy savings significantly. However, whether and which revisions are adopted are not yet known. The electric savings estimated in this work for the adoption of the 2012 IECC are small on a unit area basis. Because of the large amount of preference utility floor area estimated for Washington, the overall state savings are still comparable to the other states. If the final code proposal achieves significantly higher unit area savings, it will have a significant influence on regional savings.

Table 1. Potential Annual Electric Savings and Costs for Adoption of Next-Generation Codes in BPA's territory

Code & Provision	Cost ($/ft²)	Annual Savings (kWh/ft²)	(aMW)	(%)
Idaho/Montana				
Mandatory	$ 1.03	0.66	0.071	4.5%
HVAC option	$ 0.59	0.05	0.005	0.3%
Lighting option	$ 0.19	0.47	0.05	3.2%
Oregon				
Mandatory	$ 1.32	0.87	0.195	6.0%
HVAC option	$ 0.75	0.09	0.019	0.6%
Lighting option	$ 0.05	0.42	0.094	2.9%
Washington				
Mandatory*	$ 0.33	-0.23	-0.362	-1.9%
HVAC option	$ 0.61	0.08	0.125	0.7%
Lighting option	$ 0.20	0.40	0.643	3.4%
Regional total				
Mandatory plus lighting option	$ 0.66	0.36	0.693	2.7%

Compliance requires meeting mandatory provisions and one option. Savings are based on all forecasted BPA territory new construction complying with the state's next-generation code. Savings and cost are calculated from a standard practice baseline. *The negative values are due to the mandatory provisions being less efficient than the current Washington State code.

The 2012 IECC and Oregon Reach codes differ from the existing regional codes in that they include mandatory provisions and a set of increased-efficiency options, from which projects must choose one. The Oregon Reach also requires a project to complete two electives from a list that includes energy and non-energy electives. Because lighting is the most cost-effective optional item and a significant driver of electric savings, any early-adoption incentive offered by an electric utility for meeting next-generation codes should require that buildings choose the lighting option to maximize electric savings. Other options, such as heating, ventilation and air conditioning systems (HVAC), result in less electric savings.

Lighting power and controls account for most (73%) of the electric savings in Idaho / Montana and in Oregon (63%) for buildings complying with the mandatory requirements plus the increased lighting efficiency option. Partially because of the high saturation of gas heating, envelope measures only account for 18% of savings in Idaho / Montana and 24% of savings in Oregon.

Projected New Nonresidential Floor Area

Roughly forty percent of the Northwest's new commercial floor area is forecasted to occur in BPA territory. Sixty-five percent of this construction is projected to occur in utility territories with dedicated nonresidential new construction program staff, which means that these buildings have the opportunity for a higher level of utility support for constructing their projects efficiently.

Washington is projected to have a higher rate of new construction than other Northwestern states. This, combined with the high percentage of public utilities in Washington, is why 83% of nonresidential new construction square footage in BPA's territory is projected to occur in Washington.

BPA New Nonresidential Program Findings and Recommendations

The majority (72%) of BPA's new construction savings from program activity is through the lighting program; the remainder is through the custom project process. Because much of the new construction savings from code are anticipated in lighting, BPA should ensure that the lighting new construction offering continues to push the market to higher efficiencies in lighting than required by code.

- Increases in lighting efficiency required by code will approach the levels that BPA currently requires in its lighting program. The BPA lighting program requires a minimum 20% savings over a baseline target. Savings from future code mandatory requirements combined with the high-efficiency lighting option will approach this 20% program goal, except in Washington.
- The BPA lighting calculator has the flexibility of potentially counting savings beyond 20%. The calculator also offers an easy compliance path for new small and remodel/renovation projects to achieve a significant portion of available electric savings.
- BPA should consider implementing an increased incentive per fixture as the percentage savings increases. Currently, the program structure does not provide an incentive to achieve more than the required 20% savings. Incentives decrease as the fixture count decreases, meaning, that the decrease in energy usage from smart lighting design is not incented. This does not leverage savings from better lighting design.
- The lighting calculator data archived as part of the submission process should be expanded. At a minimum, submissions should include project area, final lighting power density (LPD), controls credit, building type, measure specifics, and calculator version number. This data will facilitate evaluation work in order to verify savings.
- There is great uncertainty around program lighting savings. Understanding the lighting savings estimated by the current calculator is difficult due to baseline uncertainty. This does not mean that the program is not delivering savings, just that they are uncertain. The lighting calculator should be audited and adjustments made to ensure that issues related to base LPD, base and proposed code control credits, and explicit treatment of non-incented fixtures in the proposed case are addressed appropriately. Steps in this direction have been initiated by BPA.
- Maximum lighting power requirements in next-generation codes assume lighting technology similar to the current technologies included in the BPA lighting program. At a minimum, consideration should be given to extending the lighting technology requirements to include fixture efficiency.
- It is recommended that consideration be given to developing incentives based upon performance path compliance modeling. Performance path (modeling) options are expanded in the 2012 IECC and Oregon Reach. The Oregon Reach requires buildings over 70,000 ft^2 to use the performance path. If a modeling-based incentive program could be developed, it could be used in general outline in all states. It also would provide a means of offering incentives for performance beyond next-generation code compliance. Since performance path code compliance is fuel blind, program criteria would need to go beyond mere code compliance and require documentation of electric savings.

Introduction and Purpose of Report

As a national leader in the adoption of progressive building energy codes, the Northwest is faced with the problem of how to maximize savings from code changes and programs. This report forecasts code savings and quantifies associated total costs in an effort to evaluate the best path forward in maximizing savings through code changes and energy efficiency programs in nonresidential buildings. The forecast is confined to nonresidential floor area served by BPA preference utilities. The savings estimates are true energy, reflecting standard practice baselines where it is more stringent than code.

Background

Building codes have rapidly increased in efficiency over the last decade, serving as a state policy tool to meet greenhouse gas reductions and increase energy efficiency for consumers. Because of the size of the increases, the transition to new codes has been challenging for the building industry. In an effort to smooth out those transitions, states such as Massachusetts and Oregon have developed more stringent voluntary codes as an indicator of where the code is heading. These are commonly referred to as next-generation or stretch codes and not only ready the market, they provide a basis for the next round of code negotiations.

In 2009, Oregon Senate Bill 79 included a provision to develop a state-sponsored voluntary energy code known as the Oregon Reach Code. This stretch code was designed to help Oregon meet its statewide goal of a net-zero building code by 2030, which will require substantial increases in building efficiency. The State of Oregon has developed marketing and outreach support for the implementation of this code, which is based on the International Green Construction Code. The Oregon Reach Code will be the basis for the next mandatory (minimum) Oregon energy code in 2013.

Idaho and Montana currently enforce the 2009 International Energy Conservation Code (IECC). These states do not have a declared reach code but as IECC adopters, the IECC 2012 will be the next code considered and therefor is considered the next-generation code. In contrast to Oregon, however, Idaho and Montana do not support IECC 2012 early adoption through marketing or other activities, and have made no commitments to adopt it. Even if adopted, the next-generation code likely will not be in effect until 2014 or later.

Washington is currently undergoing a change in the structure of their codes, as they move to the IECC code format from their state code. In the past, Seattle's building code often served as the *de facto* stretch code as high-efficiency practices or codes were adopted in Seattle and would later be integrated into the Washington state code. However, with the transition to 2012 IECC, which in many ways is less efficient than the current Washington code, it is anticipated that significant modifications will be adopted. As such, there is no clear path to gauge the next code provisions in Washington State.

Overview of Current and Future Codes

The table below summarizes current code for Northwest states and the most likely future energy code in each of those states.

Table 2. Current and Evaluated Future Nonresidential Energy Codes

State	Current Code	Future Code
Idaho	2009 IECC	2012 IECC
Montana	2009 IECC	2012 IECC
Oregon	2010 Oregon Energy Efficiency Specialty Code (OEESC)	Oregon Reach Code (ORC)
Washington	2009 Washington State Energy Code (WSEC)	2012 IECC

The codes all have a prescriptive path and a performance path of which buildings must pass one to achieve compliance. The prescriptive path defines a set of minimum equipment requirements with which buildings must comply. The performance path requires engineering models to calculate the total building energy use and compare the proposed building to a baseline building. This evaluation is limited to the prescriptive paths, as they are most similar to current BPA offerings, most easily guarantee electric savings, and can be easily implemented by all utilities in a programmatic approach.

The prescriptive paths of next-generation codes (2012 IECC and Oregon Reach) differ from existing codes in that they have mandatory requirements plus three high-efficiency options from which projects must choose one. The Oregon Reach Code also requires two project electives from a long list ranging from energy, materials, and process improvements. The combination of options and electives results in multiple energy savings outcomes that vary significantly with respect to magnitude and fuel type.

Report Structure

We start this report with a discussion of methodology followed by analysis results. The third section analyzes the intersection of codes and BPA programs.

The details of the structure of and compliance options in the Oregon Reach Code are discussed in Appendix A, and the 2012 IECC is discussed in Appendix B. Code measure evaluation details are discussed in Appendix C. Detailed lists of differences between the current and future codes and the current regional codes are included in Appendices D, E, and F. Detail savings estimates by state, code provision, and utility type are presented in Appendix G. Appendix H contains a memorandum describing development of estimates of preference utility distribution across the region.

Methodology and Data Sources

This chapter discusses the data sources used in the project and the methodology to estimate new floor space, costs and savings.

Determining the energy savings from the various code increments consisted of the following tasks, brought together in final regional calculation spreadsheets:

- Identify code changes and prioritize for evaluation
- Determine building characteristic changes resulting from the code changes
- Develop prototypes and model base building energy use
- Calculate measure savings using direct simulation or engineering calculations based upon base model end-use estimates
- Combine regional floor area with savings calculations

Data Sources

NEEA New Construction Survey Characteristics

The primary characteristics data used in this work are derived from data collected as part of the research for the "NEEA Baseline Characteristics of the 2002-2004 Nonresidential Sector" (Ecotope 2008)[1]. This data is used to determine HVAC equipment type; performance, and associated minimum code performance; building lighting power densities (LPD) and associated code maximum LPD; and building envelope characteristics and geometry. The study buildings were built to the standards current during the 2001 code year. As such they do not necessarily comply with the 2008 codes used as the base for this work. Adjustments were made where appropriate. This data set is referred to as the NEEA New Construction Survey.

NPCC Sixth Plan and Floor Area Forecast

The Northwest Power and Conservation Council (NPCC) has developed several key regional information sources. The NPCC Sixth Power Plan evaluates energy savings and cost of a full range of electric energy conservation measures. Cost data and some savings factors have been borrowed from this work. Although highly generalized, many of the cost estimates are based upon a thorough literature review.

The NPCC also produces a regional floor area forecast. The most recent forecast is from September 2009 and estimates new nonresidential floor area by state and building type. This estimate is used to determine the overall new construction floor area by state and building type.

RW Dodge New Construction Data

RW Dodge data for six years of new northwest construction activity (2002–2007) were used to determine the geographic distribution of new construction within each state. This distribution was used to determine the fraction of state floor area served by BPA preference utilities.

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[1] http://www.nwalliance.org/resources/reportdetail.asp?RID=134

Floor Area Estimation Methodology

The NPCC new construction floor area forecast is used to determine the total new floor area expected for each state and building type. The average annual new construction forecast for the period from 2013 through 2022 is the basis for all results.

Regional estimates of BPA preference utility floor area were subdivided into three programmatically important groups:

- Small, rural residential utilities (SRR)
- Utilities with active new construction programs - Program Involvement - High (PIH)
- Utilities without active new construction programs - Program Involvement - Low (PIL)

To adjust regional estimates for BPA preference SRR, PIL, and PIH utility territories, multipliers were developed based upon the fraction of RW Dodge cataloged projects between 2002–2007 occurring within each utility type. These multipliers are applied to the forecasted state and building type floor area to generate total preference utility, as well as SRR, PIL, and PIH utility floor areas.

Evaluated Code Changes

The first step of this project was to identify all code changes between the current state energy codes and the assumed next-generation code. The list of code provision changes were prioritized by anticipated magnitude of energy savings and reviewed by NEEA, and then the code changes to quantitatively evaluate were chosen. Table 3 presents the measures evaluated. Every energy code difference is listed by state in Appendices D through F with an indication of whether it has been evaluated and, if not, the reasoning for exclusion.

Table 3. Evaluated Measures

Code Provisions	ID/MT	OR	WA
Mandatory			
Continuous Air Barrier	X	X	X
Automatic Lighting Controls	X	X	X
Boiler Efficiency	X		
Package Terminal Heat Pump Efficiency	X	X	X
Commissioning	X	X	
2010 Equipment Efficiency EER Changes	X	X	X
Envelope Changes	X	X	X
LPD Changes	X	X	X
Minimum Skylight Area	X	X	X
Key Mandatory Provision Not Evaluated			
Advanced VAV - Reheat Limited to Ventilation Needs (OR)			
New Fan Power Requirements (WA)			
Increased-Efficiency Options			
HVAC Equipment	X	X	X
LPD and Warehouse Daylighting	X	X	X
Renewables (PV Assumed)	X	X	X
Oregon Reach Project Electives			
Renewables (OR Only)		X	
DHW Equipment (OR)		X	
Envelope (OR)		X	
Washington Diminished Provisions			
ECM Motors No Longer Required in Series Fan-Powered Boxes (WA)			X
Economizer (WA)			X
Egress Light Control Reduction (WA)			X
Elimination of Dampers Closed During Night Cycling (WA)			X
Elimination of OS Control of Local Dampers (WA)			X
Grocery HR Reduction (WA)			X
Side Daylight Control Reduction (WA)			X
Single Zone VAV Requirement Elimination (WA)			X
Top Daylight Control Requirement Reduction (WA)			X
Exhaust Air Heat Recovery Reduction (WA) *Not Currently Evaluated*			

Many code provision changes have not been evaluated in this work. Typically they impact a limited number of buildings or system types. Individually they are not important, but taken together they represent additional savings not captured in these estimates. This is particularly true in evaluating the change from the 2009 WSEC to the 2012 IECC, where literally hundreds of items changed. In the Washington case many of the items lead to energy losses rather than savings, as the 2012 IECC is less stringent in many aspects, but for the other code increments they form a slight bias to underestimating savings.

Climate zone plays an important factor in the Idaho and Washington envelope requirements and a small factor in the mechanical codes. These climate zone differences are evaluated separately; modeled with the appropriate weather; and combined with population estimates for the given climate zone.

The 2009 WSEC currently has two climate zones, and the 2012 IECC has three Washington climates zones. The IECC boundaries do not coincide with the current Washington zone boundary, so there are four different code combinations. To simplify the analysis, one of the IECC zones (6b) has not been evaluated. This zone encompasses four small rural counties in Washington representing 0.8% of new nonresidential floor area. This floor area was lumped with the next closest zone. In sum, this analysis considers three different envelope increment/climate combinations in Washington.

Details on the evaluated measures and individual savings calculations can be found in Appendix C and in the calculation spreadsheets.

This evaluation compares changes in the code prescriptive paths only. No attempt is made to compare performance paths, alternate compliance paths, or compliance tool (e.g. Comcheck) results. This is an important caveat, as several codes have significant alternative paths that likely lead to lessened or different requirements. For example, Oregon Reach requires buildings over 70,000 ft^2 to use the performance path rather than the prescriptive path. In Idaho and Montana, the IECC allows users the option to comply with the previous version of ASHRAE 90.1. For the current base codes this is 90.1 - 2007. Since ASHRAE 90.1 - 2007 has more lenient requirements, projects are choosing to comply with 90.1[2]. With the next-generation 2012 IECC, the alternate path will reference ASHRAE 90.1 - 2010, and the relative performance between the compliance paths will lessen. Savings calculated based upon the prescriptive change between the 2009 and 2012 IECC will not capture this.

The 2012 IECC and Oregon Reach prescriptive codes differ from the existing regional codes in that they include mandatory provisions and a set of increased-efficiency options, from which projects must choose one. In addition the Oregon Reach requires a project to complete two electives from a list that includes energy and non-energy electives. This makes characterizing savings difficult, as the quantity and fuel type of the savings are impacted by the option chosen. Appendix A provides a detailed discussion of the codes and various options.

Savings Estimation

Energy savings from code provisions are estimated using building energy simulation supplemented with engineering calculations. Savings estimates are made on a unit area basis for each building type/state combination. Total state and regional savings estimates combine the unit area savings estimate with the new construction/addition floor area forecasts from the Northwest Power and Conservation Council (NPCC) Sixth Power Plan[3]

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[2] Personal communication with Ken Baker

[3] Supporting data files from: Sixth Northwest Electric Power and Conservation Plan, Northwest Power and Conservation Council, Document 2008

and estimates of the fraction of regional new construction served by BPA preference utilities[4].

Prototype building descriptions were modeled to determine savings from incremental changes in the primary performance variables (e.g., lighting LPD, equipment efficiency, and envelope component efficiency). The simulations were also used to establish baseline energy use, which underlies all engineering estimates.

The savings estimates made here are not a direct code-to-code comparison, but rather a standard practice–to-code comparison. Current building performance is accounted for, which in most cases results in diminished savings. If 50% of the current buildings already incorporate a technology required in the new code, savings are not claimed for those early adopters. Similarly, cost estimates assume that current better-than-code buildings will continue to adopt the technology without applying for program money.

Savings Calculation Spreadsheets

All savings and cost calculations are processed through spreadsheets that combine simulation results, engineering calculations, and population estimates. A calculation spreadsheet has been created for each geographic area, customer group, and code increment being examined. The spreadsheets contain a worksheet for each evaluated provision. The energy savings and cost per square foot are calculated and the savings and cost estimates combined with the appropriate floor area as determined by state, climate zone, customer type, and various technology applicability factors.

Unit area savings for a code provision are calculated either through direct simulation or engineering calculations. Where measures are directly modeled, the calculation spreadsheets link to the simulation results, which are stored in a central simulation results spreadsheet. Engineering calculations apply engineering calculations and/or field evaluation results to the simulation predicted end-use consumption.

The spreadsheets estimate energy savings for different heating fuels and heating fuel saturation factors as determined from the NEEA New Construction Survey.

To arrive at sector savings, the savings per floor area estimates are combined with the forecasted floor area for the given population group and building type. The floor area estimate is adjusted further to account for the applicability of the code language to the given building, heating fuel, system types, or other factor, and for the current saturation of the technology. Total saturation is the assumed end result. All applicable buildings without a particular required technology are assumed to install it.

Prototype Buildings and Simulations

Simulations were conducted using the eQUEST building energy simulation program and prototypical buildings developed by the US Department of Energy. The eQUEST program was chosen to make use of its batch processing capabilities and so that the resulting building descriptions would be easily adaptable for other BPA work.

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[4] Described in April 10, 2012 memo titled "BPA Utility Adjustments to NPCC Nonresidential New Construction Floor Area Forecasts" (See Appendix H)

Table 4 lists the fourteen models utilized to represent the general building stock. The prototypes are directly derived from models developed by PNNL to estimate savings from ASHRAE 90.1. Since the PNNL models were developed using the EnergyPlus building simulation software the descriptions were translated to eQUEST. The translations attempt to model the buildings as close to the PNNL approach as possible, though they are approximate in many aspects, as the programs have differing capabilities and approaches. Documentation of the prototype characteristics can be found at the PNNL repository for the 90.1 evaluation work. In particular, the score card spreadsheets are useful, though in some cases the actual PNNL models deviate from the published scorecard descriptions.

Table 4. Prototype Descriptions

Building Type	Baseline System/Fuel
Office – Large	VAV – fanless terminals. Gas boiler, hot water reheat.
Office – Medium	VAV – fanless terminals. Gas furnace, electric reheat.
Office – Small	Split system single-zone heat pump, gas auxiliary
Retail – Large	Package single-zone, gas heat
Retail – Small	Package single-zone, gas heat
Grocery	Package single-zone, gas heat
School – Secondary	VAV – fanless terminals. Gas boiler, hot water reheat. Package single-zone with gas furnace for some common areas.
School – Primary	VAV – fanless terminals. Gas boiler, hot water reheat. Package single-zone with gas furnace for some common areas.
Warehouse	Package single-zone, gas heat. Unit heaters.
Hospital	VAV and CAV – fanless terminals. Gas boiler, hot water reheat.
Restaurant – Sit Down	Package single-zone, gas heat
Restaurant – Fast Food	Package single-zone, gas heat
Lodging – Hotel	Common areas: VAV; rooms: four pipe fan coils
Lodging - Motel	Common areas: package single-zone, gas heat; rooms: PTAC

The base model characteristics for LPD, window-to-wall ratio, envelope, and equipment efficiency for each prototype were updated for each climate zone based upon NEEA New Construction Survey data (See Data Sources). The survey buildings are built prior to the 2012 codes used as a base for this evaluation; therefore, data were modified to represent 2012 buildings using one of the code compliance scenarios discussed later. The base LPD is neither the average NEEA New Construction Survey LPD nor the 2012 base code LPD, but the average NEEA New Construction Survey building LPDs modified for predicted response to the 2012 base code. This results in a base level better than the 2012 code in all cases.

All NEEA New Construction Survey buildings are used to set characteristics for each code no matter where the building is actually located. The use of all buildings allows much better building type characterization, which has a critical impact on energy savings. To the extent that Idaho buildings are built with different materials or a different mix of spaces, this treatment will introduce error. This trade-off was deemed worthwhile. Use of the scenarios discussed later minimizes climate issues that might result from this approach.

Table 5 lists the climate zones used in modeling the various code increments. In all cases TMY2 weather data were used.

Table 5. Weather Data

State	Climate Zone	Weather Station
Idaho	Zone 5	Boise ID
Idaho	Zone 6	Missoula MT
Montana	Zone 6	Missoula MT
Oregon	Zone 5 and Marine 4 (west side)	Salem OR
Oregon	Zone 5 and Marine 4 (east side)	Redmond OR
Washington	WSEC Zone 1 to IECC Marine 4	Seattle WA
Washington	WSEC Zone 1 to IECC Zone 5	Seattle WA
Washington	WSEC Zone 2 to IECC Zone 5	Spokane WA

Each prototype has a single heating fuel chosen to represent the most common fuel by building type. The final calculation spreadsheets calculate electric, gas, and heat pump heat from the default system consumption using simplified conversion factors. Average energy consumption by building type is determined in the calculation spreadsheets by combining the consumption for each heating fuel case with the regional heating fuel type saturation found in the NEEA New Construction Survey data. Lost in this method is the impact of significant changes in system types or building configuration in the future. The world is seen through the lens of the audit data, which reflects the design choices of the past.

Determining Code Change Increments

For the primary building performance criteria (maximum lighting power density [LPD], envelope thermal performance, and cooling efficiency) the chosen incremental change has a significant impact on savings. A majority of code energy savings studies look at the arithmetic code-to-code change as the incremental change. Using an LPD example, if the old code required a 1.4 W/ft^2 LPD and the new code requires 1.2 W/ft^2, the code-attributed reduction in lighting power is 0.2 W/ft^2.

The code-to-code increment produces an estimate of the upper bound of possible savings and has several limitations. Every study of northwest buildings has found that average new building characteristics exceed the average code requirements. For example, in the NEEA New Construction Survey, the average building LPD is 1.10 W/ft^2, while the average code-required LPD for those buildings at the time of construction is 1.30 W/ft^2. Using the arithmetic code-to-code change takes credit for saving the nonexistent lighting power between the two code numbers.

For this and other reasons the arithmetic code-to-code scenario has not been used in this or in previous evaluations of Northwest energy code savings. Instead, the response of a given trait to a code is estimated for each building in NEEA New Construction Survey inventory. The estimated traits are averaged by building type and become the model input parameter for the particular code case. The estimated response depends upon the trait and code case being estimated and is determined using the following hypothetical constructs.

The most basic and conservative hypothetical response is the compliance scenario. The compliance scenario looks at code response as a code official would. It assumes that buildings not meeting the proposed code will meet it and that buildings already better than code will not change. In the case of LPD, if the building LPD is above the code maximum LPD

it is assumed to improve to the code requirement, but if it is better than code it is assumed to not change. This estimated LPD is averaged by building type to estimate the final LPD. The assumption that buildings will move to the new code level but not beyond makes this the most conservative estimator. It has been called the "first year savings" in previous regional code savings evaluation (Kennedy & Baylon, 1992).

The proportional scenario assumes a proportional shift in the building population characteristics. It assumes that a 10% improvement in the code requirements will improve the installed building LPD by 10%. Future buildings are assumed to pass the new code by the same relative margin that recent buildings passed the code that was in effect at the time of their construction. It assumes a building built *x*% better or worse than the base code will be *x*% better or worse than the new code if it were built now. Unlike the compliance scenario, a building will show savings even if it is already better than the new code. Unlike the arithmetic code-to-code approach, the incremental change will never exceed the as-found building characteristic.

An intermediate scenario between the compliance and proportional scenarios is a modified version of the compliance scenario, "Compliance+5%," which was developed and used to evaluate lighting LPD changes in past work. The purpose was to provide a savings increment that was not as conservative as the compliance scenario but that was not extravagant when evaluating cases with nonexistent or outdated base codes. It assumes that buildings surpassing a code by 5% will not change and that everything else will improve to exceed the code by 5%. This scenario addresses the fact that new buildings will typically exceed code by some margin; in terms of savings potential it falls midway between the compliance and proportional shift scenarios.

A more complete discussion of this issue can be found in the 2011 NEEA Energy Code Evaluation (Kennedy, 2011) along with the implied after-code LPD for the NEEA New Construction Survey buildings for each scenario and code.

Application of the Savings Scenarios

In this work the proportional and compliance +5% scenarios are both used. Generally, the compliance +5% scenario is applied to items such as fenestration solar heat gain coefficients (SHGC) where code has just caught up to current practice. In Montana, the compliance +5% and compliance scenario are generally used because there was no Montana energy code when many of the NEEA New Construction Survey buildings were audited, so the original percentage better or worse than code cannot be determined.

A proportional scenario has been used for thermal conductance changes in Idaho, Oregon, and Washington buildings, and the compliance +5% scenario in Montana buildings. For SHGC, the compliance scenario is used in all buildings.

For lighting power density all scenarios have deficiencies, which makes application to all situations difficult. The compliance scenario is too obviously conservative, and the proportional and code-to-code scenarios give unreasonable results where the base code at the time the building was built has very high maximum LPD values that do not represent current practice well. If current practice is the result of desired light levels and not the code, then these savings are illusory. In this evaluation the Idaho, Oregon, and Washington lighting codes are evaluated with the proportional scenario. The Montana lighting code changes are evaluated assuming the compliance +5% scenario.

The proportional shift scenario was used for savings from equipment cooling and heating efficiency and heat pump heating efficiency. The equipment efficiency base code is set at a national level and was assumed to be effectively active in Montana even though there was no energy code.

Engineering Method

Measures such as motor control and lighting control improvements were evaluated using a simplified engineering approach. This approach was chosen when modeling was difficult within the confines of eQUEST and the prototypes, or when modeling an "average" case was difficult and/or the model inputs would directly predict savings. For example, savings from a control strategy such as occupancy sensors are not modeled but are determined by applying a savings factor derived from field evaluations.

Engineering calculations are implemented in the calculation spreadsheets. Generally, savings are calculated using engineering calculations based upon total energy use or on the energy used for a specific end use, as determined from the prototype simulations. If applicable, engineering calculations utilize lighting measure interaction with HVAC factors developed from the simulations.

As with the simulation results, the savings are modified to account for heating fuel saturations and the applicability of the code language to given building or system type. The applicable population is also adjusted to exclude current saturation of the technology. All applicable buildings without a particular required technology are assumed to install it. To minimize double counting, end use consumption and interaction factors were taken from simulations that incorporated code characteristics for LPD, UA, and HVAC performance.

Cost Determination

Incremental cost estimates have been developed for each next-generation code. The number and complexity of the various compliance paths and the component/equipment types make costing a challenging objective. These are preliminary estimates developed primarily with information from secondary sources. The costs are heavily generalized and should be refined and updated if specific codes and compliance paths become of specific interest. Details of measure costing are presented with the measure discussions in Appendix C. In the calculation spreadsheets there are additional notes with the cost calculations.

Estimates are of first cost for all measures except lighting LPD. For most next-generation code provisions, the change in O&M cost is minimal. Lighting LPD and control measures are a significant exception, with some higher efficiency paths having lower O&M costs, and some control measures limiting the hours of operation and therefore extending the equipment lifecycle. The cost data for LPD is derived from the NPCC Sixth Plan and accounts for changes in O&M, primarily lamp and ballast replacement costs. Lighting control measures do not account for control O&M or increased lamp life.

Costs have not taken into account changes in HVAC system capacity that might be allowed or required from changes in lighting and envelope measures. This is a very significant factor but beyond the scope of the current effort. Generally, required system capacities decrease by 3% from the mandatory code provisions evaluated, which could reduce the incremental cost of the future code by as much 30%.

Cost data were normalized to 2012 dollars. Adjustments were made based upon the CPI-u index through 2011. For 2012 it was assumed that the CPI-u will increase an average 2% above the 2011 average. A common cost source is the NPCC Sixth Plan, which used 2008 dollars. The cost adjustment was developed as presented in Table 6.

Table 6. CPI Cost Adjustment (2008 to 2012)

Year	Annual Average CPI-u
2008	215.303
2011	224.939
2012	229.438
2008 to 2012 inflator	1.06565

Where new costs are developed, a 17% general contractor markup was included to cover the variable portion of the contractor's overhead as well as taxes and profit. For costs borrowed from other work, it was often not possible to ascertain the cost assumptions with respect to markup, and these costs were used as is.

Regional differences in costing are not accounted for in the tables of these reports. The cost estimating firm that provided many of the envelope increment costs also provided estimates for envelope and lighting/mechanical measures for several geographical areas. In general, the variation in envelope measures is minimal, while lighting and mechanical measures range 9% from high to low. The indices in Table 7 can be used to adjust the cost estimates in this report if desired. These costs factors do not include differences in sales tax.

Table 7. Cost Index for Regional Cities (100 = Reference Cost)

City	Envelope	Lighting/Mechanical
Seattle WA	100.0	100.0
Richland WA	101.5	101.2
Portland OR	100.6	100.1
Klamath Falls OR	100.4	100.3
Boise ID	98.3	93.5
Lewiston ID	100.5	96.2
Billings MT	99.4	93.4
Havre MT	99.1	92.8

Nonresidential Floor Area Results

The savings and cost estimates required the development of estimates of new commercial square footage in BPA territory. Table 8 summarizes the fraction of floor area within each state by preference utility type. The last two rows present the percentage of total regional floor area occurring in each state based upon the RW Dodge data, along with percentages based upon the NPCC forecast. The NPCC forecast estimates that the portion of regional new construction occurring in Washington will increase compared with the historical pattern shown in the RW Dodge data.

Table 8. Nonresidential New Construction by State and Utility Type (% of State Floor Area)[1]

Preference Utility Type	ID	MT	OR	WA	Region 2002–2007	Region 2013–2022
Rural	9.8	6.8	7.2	6.0	6.9	6.5
Program Involvement – Low	2.4	26.1	7.8	8.1	7.7	7.6
Program Involvement – High	0.0	0.0	7.5	38.9	23.4	25.9
Non-Preference Utilities	87.8	67.1	77.5	47.0	62.0	60.0
All Utilities	100.0	100.0	100.0	100.0	100.0	100.0
State Fraction 2002–2007 Dodge	14.9	2.9	27.4	54.8	100.0	
State Fraction 2013–2022 NPCC Forecast	9.9	3.2	23.1	63.8		100.0

1- These are approximate. Actual factors are developed by building type and state, so as the forecasted building mix changes, there are minor shifts in the state level fractions.

Table 9 presents the distribution of preference floor area by preference utility type and state. The combination of a strong forecast for construction and the high floor area fraction served by BPA in Washington, results in nearly 83% of the forecasted new construction for BPA territory occurring in Washington. Further details on the development of square footage estimates for BPA territory are available in Appendix H.

Table 9. Forecasted Nonresidential New Construction by State and Preference Utility Type (% of Floor Area Served by Preference Utilities)

Preference Utility Type	ID	MT	OR	WA	Region
Rural	2.7	0.6	3.8	9.1	16.3
Program Involvement - Low	0.5	1.7	4.0	12.7	18.9
Program Involvement - High	0.0	0.0	3.7	61.1	64.8
All Preference Utilities	3.2	2.3	11.6	82.9	100.0

Cost and Savings Results

This section of the report presents the results from the cost and savings analysis.

As illustrated in Table 10, Idaho and Montana mandatory provision electric savings are 0.66 kWh/ft^2 representing a 4.4% decrease in total electric consumption and costing \$1.03/ft^2. The lighting option significantly increases the savings when added to the mandatory provisions. With the LPD increased-efficiency option, electric savings increase by 0.47 kWh/ft^2 (3.2%), and cost increases \$0.19/ft^2. In contrast, HVAC has a limited effect on electric savings across the population. If the HVAC increased-efficiency option is pursued, then electric savings increase by 0.05kWh/ft^2 (0.3%), and cost increases \$0.59/ft^2. Electric

savings attributed to the Renewable options (PV) are not savings per se but are the electric energy produced by the assumed photovoltaic renewable energy system.

The Oregon savings are larger, with the mandatory provision electric savings of 0.87 kWh/ft^2 or 6% of total electric consumption. The total cost of the mandatory provisions is \$1.32/ft^2. The climate difference is apparent here, with Oregon's gas energy savings smaller but the percentage savings higher than the Idaho/Montana savings. Oregon buildings must also choose two project electives that can increase electric and/or gas savings further. The electives include those listed in the table, several non-energy electives, and the HVAC and LPD options, if they are not chosen as the increased-efficiency option.

Washington unit area savings are small. In fact, several unevaluated issues likely would show the 2009 WSEC to be even stronger than the current analysis indicates when compared with the 2012 IECC, which would further reduce savings. Due to the closeness of codes it is hard to imagine a program that is based upon compliance with the designated next-generation Washington code being assured any savings. However, the Washington State Building Code Council is currently developing the 2012 code, and as currently discussed it will be heavily modified from the 2012 IECC and should show unit savings beyond the 2012 IECC, similar to Oregon's.

Table 10. Energy Savings and Cost Summary by State (Gas- and Electric-Heated Buildings)

State	Provision		Unit Savings		Cost	Floor Area	Sector Savings		Cost	Savings	
			Electric (kWh/ft^2)	Fuel (kBtu/ft^2)	USD \$/ft^2	(millions ft^2)	Electric (aMW)	Fuel (MMBtu)	USD (1000s)	Electric (%)	Fuel (%)
ID/MT	Mandatory		0.66	2.71	1.03	0.93	0.071	2517	959	4.5	10.7
ID/MT	Option	HVAC	0.05	2.33	0.59		0.005	2162	549	0.3	9.2
ID/MT		LPD	0.47	-0.64	0.19		0.050	-596	176	3.2	-2.5
ID/MT		PV	0.35	0.00	1.68		0.037	0	1562	2.3	0.0
OR	Mandatory		0.87	2.33	1.32	1.95	0.195	4552	2574	6.0	11.8
OR	Option	HVAC	0.09	1.70	0.75		0.019	3309	1464	0.6	8.6
OR		LPD	0.42	-0.35	0.05		0.094	-688	105	2.9	-1.8
OR		PV	0.32	0.00	1.57		0.072	0	3059	2.2	0.0
OR	Elective[1]	DHW	0.00	0.24	0.00		0.000	470	0	0.0	1.2
OR		Env	0.06	0.46	0.29		0.014	904	557	0.4	2.3
OR		PV1[2]	0.21	0.00	1.01		0.046	0	1978	1.4	0.0
OR		PV2[2]	0.18	0.00	0.89		0.039	0	1728	1.2	0.0
WA	Mandatory		-0.23	-0.07	0.33	13.99	-0.362	-1027	4666	-1.9	-0.5
WA	Option	HVAC	0.08	1.38	0.61		0.125	19327	8552	0.7	9.6
WA		LPD	0.40	-0.41	0.20		0.643	-5687	2731	3.4	-2.8
WA		PV	0.26	0.00	1.27		0.418	0	17816	2.2	0.0

1- If the HVAC and/or LPD is not used for Increased-Efficiency Option, then it is available as project elective.
2- If the renewables Increased-Efficiency Option is not used, then PV1 is the available elective. Otherwise, PV2 is the available elective.

Table 10 also presents annual savings and cost for all floor area served by preference utilities. The forecasted new floor area is based upon the NPCC floor area forecast combined with state preference utility fractions, as shown in Table 8 and Table 9.

Figure 1 and Figure 2 attribute electric savings to individual code provisions. Figure 1 presents the percentage of total electric savings for the 2012 IECC mandatory prescriptive elements with the LPD increased-efficiency option, in the Boise climate. Figure 2 presents

the percentage of total electric savings for the Oregon Reach mandatory prescriptive elements with the LPD increased-efficiency option, in the Salem climate. The impact of the required two electives is not included in this figure. Lighting power and controls account for 70% of the mandatory electric savings in Idaho and 63% in Oregon. Envelope insulation and air barrier measures account for 14% of savings in Idaho and 20% of savings in Oregon. Commissioning also contributes significant savings, though the basis of the commissioning savings estimate is uncertain, as discussed in the methodology section. HVAC equipment requirements do not appreciably change in the new mandatory requirements.

If the PV increased-efficiency option is selected, then the overall savings (generation) are slightly less than the LPD option presented in the figures. If the HVAC increased-efficiency option is selected, then the overall electric savings are reduced by 30% to 40%.

Figure 1. Idaho Zone 5 Electric Savings by Measure (% of Mandatory Plus Increased-Efficiency LPD Option Savings)

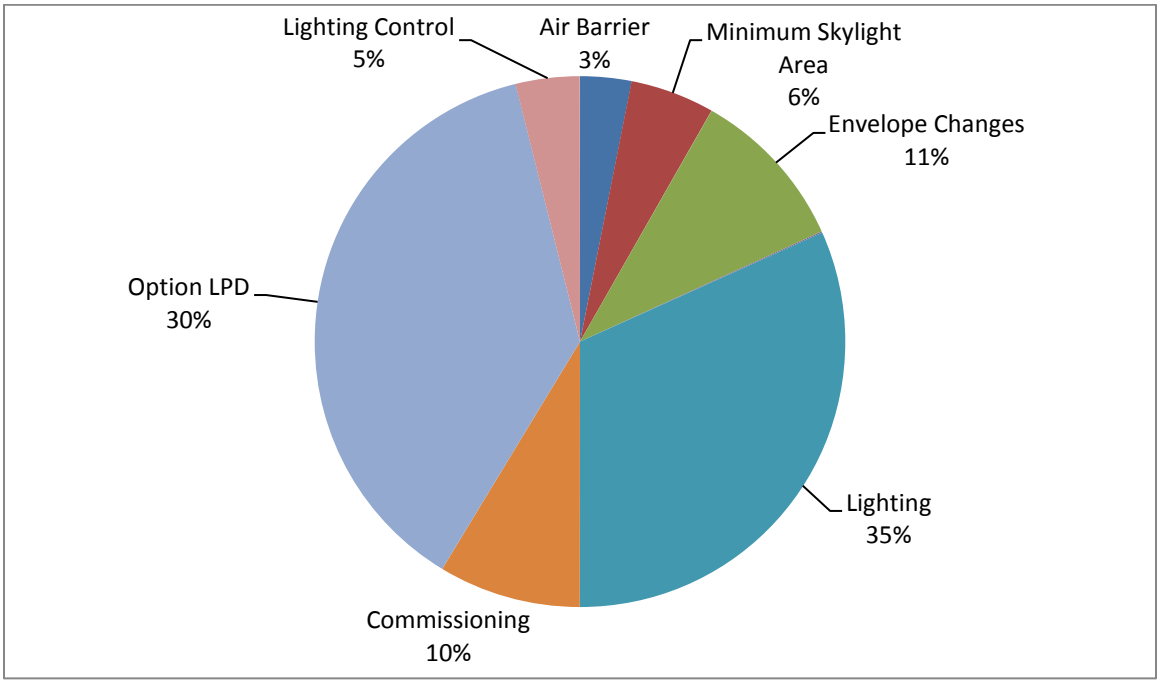

Figure 2. Western Oregon Electric Savings by Measure (% of Mandatory Plus Increased-Efficiency LPD Option Savings)

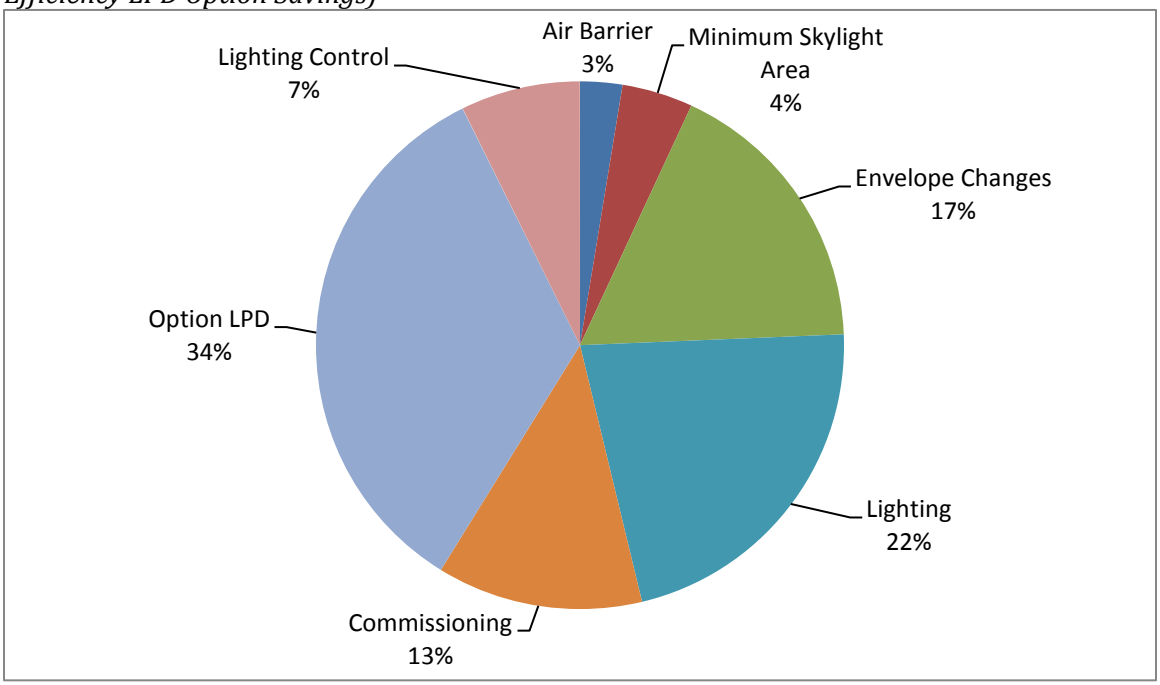

Table 11 presents savings for preference utility buildings that are heated electrically. The unit area electric energy savings are higher than those in Table 10 (gas and electric heat buildings averaged), and there are no fuel savings. The unit area costs differ from the all fuels costs because the distribution of building types differs for electric heat buildings. In this work the distribution of electric heat floor area is taken from the NEEA New Construction Baseline Survey.

Table 11. Electric Heat Buildings - Energy Savings and Cost Summary by State

State	Provision		Unit Savings		Cost	Floor Area	Sector Savings		Cost	Savings	
			Electric (kWh/ft²)	Fuel (kBtu/ft²)	USD ($/ft²)	(millions ft²)	Electric (aMW)	Fuel (MMBtu)	USD (1000s)	Electric (%)	Fuel (%)
ID/MT	Mandatory		0.986	0.00	1.134	0.19	0.021	0	213	7.4	0.0
ID/MT	Option	HVAC	0.104	0.00	0.586		0.002	0	110	0.8	0.0
ID/MT		LPD	0.352	0.00	0.114		0.008	0	21	2.6	0.0
ID/MT		PV	0.297	0.00	1.460		0.006	0	274	2.2	0.0
OR	Mandatory		0.996	0.00	1.230	0.46	0.052	0	561	7.8	0.0
OR	Option	HVAC	0.138	0.00	0.749		0.007	0	341	1.1	0.0
OR		LPD	0.367	0.00	0.052		0.019	0	24	2.9	0.0
OR		PV	0.268	0.00	1.321		0.014	0	602	2.1	0.0
OR	Elective[1]	Env	0.138	0.00	0.293		0.007	0	133	1.1	0.0
OR		PV1[2]	0.175	0.00	0.863		0.009	0	393	1.4	0.0
OR		PV2[2]	0.108	0.00	0.531		0.006	0	242	0.8	0.0
WA	Mandatory		-0.259	0.00	0.273	3.59	-0.107	0	979	-2.4	0.0
WA	Option	HVAC	0.105	0.00	0.665		0.043	0	2390	1.0	0.0
WA		LPD	0.299	0.00	0.097		0.124	0	349	2.7	0.0
WA		PV	0.233	0.00	1.140		0.096	0	4095	2.1	0.0

1- If the HVAC and/or LPD is not used for Increased-Efficiency Option, then it is available as project elective.
2- If the renewables Increased-Efficiency Option is not used, then PV1 is the available elective. Otherwise, PV2 is the available elective.

Table 12 presents the energy savings and cost estimates for Idaho/Montana separated by preference customer category. The "All" category refers to all preference floor area in the state and is the same data listed in Table 10. There are no PIH utilities in Idaho or Montana. Unit savings and cost estimates between preference customer types vary somewhat. This results from the projected differing building type distribution within the groups and also on climate variation. Idaho is represented by two climate zones, and the preference customer types are not evenly distributed. The variation between utility types is not large, particularly in light of the overall uncertainty of the distribution of building types in these low-population subdivisions. The sector savings show more variation, which is based upon differences in projected floor area.

Table 12. ID/MT Energy Savings and Cost Summary by Preference Utility Type

Type	Provision		Unit Savings		Cost	Floor Area	Sector Savings		Cost	Savings	
			Electric (kWh/ft²)	Fuel (kBtu/ft²)	USD ($/ft²)	(millions ft²)	Electric (aMW)	Fuel (MMBtu)	USD (1000s)	Electric (%)	Fuel (%)
All	Mandatory		0.664	2.71	1.03	0.93	0.071	2517	959	4.5	10.7
	Option	HVAC	0.051	2.33	0.59		0.005	2162	549	0.3	9.2
		LPD	0.470	-0.64	0.19		0.050	-596	176	3.2	-2.5
		PV	0.345	0.00	1.68		0.037	0	1562	2.3	0.0
SRR	Mandatory		0.658	2.62	1.027	0.56	0.042	1463	574	4.6	11.2
	Option	HVAC	0.053	2.10	0.541		0.003	1177	302	0.4	9.0
		LPD	0.429	-0.57	0.199		0.028	-319	111	3.0	-2.5
		PV	0.327	0.00	1.591		0.021	0	889	2.3	0.0
PIL	Mandatory		0.673	2.85	1.040	0.37	0.029	1054	384	4.3	10.0
	Option	HVAC	0.049	2.67	0.668		0.002	986	247	0.3	9.4
		LPD	0.533	-0.75	0.176		0.023	-277	65	3.4	-2.6
		PV	0.372	0.00	1.820		0.016	0	672	2.4	0.0

SRR = Small, Rural, Residential; PIL = Program Involvement - Low

Table 13 presents the energy savings and cost estimates for Oregon separated by preference customer category. The results are very similar to those for Idaho/Montana, except there is a stronger correlation between preference customer types and climates; the PIH customers located in western Oregon and the SRR and PIL have significant exposure to the colder eastern Oregon climate. This is particularly visible in the envelope efficiency elective. The projected preference floor area by preference customer type is coincidentally very similar. The SRR and PIL utilities deliver around 70% of all preference customer savings, depending upon which options are chosen.

Table 13. Oregon Energy Savings and Cost Summary by Preference Utility Type

Type	Provision		Unit Savings		Cost	Floor Area	Sector Savings		Cost	Savings	
			Electric (kWh/ft²)	Fuel (kBtu/ft²)	USD ($/ft²)	(millions ft²)	Electric (aMW)	Fuel (MMBtu)	USD (1000s)	Electric (%)	Fuel (%)
All	Mandatory		0.869	2.33	1.32		0.195	4552	2574	6.0	11.8
	Option	HVAC	0.086	1.70	0.75		0.019	3309	1464	0.6	8.6
		LPD	0.421	-0.35	0.05		0.094	-688	105	2.9	-1.8
		PV	0.319	0.00	1.57	1.95	0.072	0	3059	2.2	0.0
	Elective[1]	DHW	0.000	0.24	0.00		0.000	470	0	0.0	1.2
		Env	0.061	0.46	0.29		0.014	904	557	0.4	2.3
		PV1[2]	0.206	0.00	1.01		0.046	0	1978	1.4	0.0
		PV2[2]	0.176	0.00	0.89		0.039	0	1728	1.2	0.0
SRR	Mandatory		0.892	2.39	1.344		0.067	1550	872	7.1	14.2
	Option	HVAC	0.077	1.52	0.738		0.006	988	478	0.6	9.1
		LPD	0.407	-0.32	0.044		0.030	-205	29	3.2	-1.9
		PV	0.293	0.00	1.449	0.65	0.022	0	940	2.3	0.0
	Elective[1]	DHW	0.000	0.19	0.000		0.000	124	0	0.0	1.1
		Env	0.063	0.48	0.282		0.005	313	183	0.5	2.9
		PV1[2]	0.191	0.00	0.947		0.014	0	615	1.5	0.0
		PV2[2]	0.149	0.00	0.764		0.011	0	495	1.2	0.0
PIL	Mandatory		0.937	2.55	1.364		0.073	1722	921	6.3	12.7
	Option	HVAC	0.093	1.74	0.823		0.007	1171	556	0.6	8.7
		LPD	0.444	-0.38	0.053		0.034	-257	36	3.0	-1.9
		PV	0.336	0.00	1.654	0.67	0.026	0	1116	2.3	0.0
	Elective[1]	DHW	0.000	0.31	0.000		0.000	210	0	0.0	1.6
		Env	0.067	0.51	0.300		0.005	343	202	0.5	2.5
		PV1[2]	0.218	0.00	1.073		0.017	0	724	1.5	0.0
		PV2[2]	0.176	0.00	0.891		0.014	0	602	1.2	0.0
PIH	Mandatory		0.773	2.04	1.244		0.056	1280	782	4.9	9.0
	Option	HVAC	0.090	1.83	0.683		0.006	1150	429	0.6	8.1
		LPD	0.409	-0.36	0.063		0.030	-226	40	2.6	-1.6
		PV	0.327	0.00	1.596	0.63	0.024	0	1003	2.1	0.0
	Elective[1]	DHW	0.000	0.22	0.000		0.000	136	0	0.0	1.0
		Env	0.052	0.39	0.274		0.004	247	172	0.3	1.7
		PV1[2]	0.208	0.00	1.017		0.015	0	639	1.3	0.0
		PV2[2]	0.203	0.00	1.005		0.015	0	632	1.3	0.0

1- If the HVAC and/or LPD is not used for Increased-Efficiency Option, then it is available as project elective.
2- If the renewables option (PV)is not used, then PV1 is the available elective. Otherwise ,PV2 is the available elective.

SRR = Small, Rural, Residential; PIL = Program Involvement - Low; PIH = Program Involvement - High

Table 14 presents the energy savings and cost estimates for Washington, separated by preference customer category. Washington savings are difficult to assess because the mandatory provision savings are negative. PIH utilities make up 74% of the preference floor area. Since PIH unit area savings are very close to the preference customer average, it is fair to deduce that 74% of all savings occur in PIH utilities.

Table 14. Washington Energy Savings and Cost Summary by Preference Utility Type

Type	Provision		Unit Savings		Cost	Floor Area	Savings		Cost	Savings	
			Electric (kWh/ft²)	Fuel (kBtu/ft²)	USD ($/ft²)	(millions ft²)	Electric (aMW)	Fuel (MMBtu)	USD (1000s)	Electric (%)	Fuel (%)
All	Mandatory		-0.225	-0.07	0.33	13.99	-0.362	-1027	4666	-1.9	-0.5
	Option	HVAC	0.078	1.38	0.61		0.125	19327	8552	0.7	9.6
		LPD	0.400	-0.41	0.20		0.643	-5687	2731	3.4	-2.8
		PV	0.260	0.00	1.27		0.418	0	17816	2.2	0.0
SRR	Mandatory		-0.209	-0.18	0.316	1.54	-0.037	-280	485	-2.2	-1.3
	Option	HVAC	0.062	1.35	0.546		0.011	2074	839	0.6	9.8
		LPD	0.365	-0.38	0.255		0.064	-586	391	3.8	-2.8
		PV	0.240	0.00	1.178		0.042	0	1810	2.5	0.0
PIL	Mandatory		-0.244	-0.05	0.337	2.15	-0.060	-114	724	-2.2	-0.3
	Option	HVAC	0.069	1.47	0.595		0.017	3161	1278	0.6	9.5
		LPD	0.451	-0.46	0.228		0.111	-981	489	4.0	-3.0
		PV	0.263	0.00	1.300		0.065	0	2791	2.3	0.0
PIH	Mandatory		-0.223	-0.06	0.335	10.31	-0.265	-634	3457	-1.9	-0.4
	Option	HVAC	0.082	1.37	0.624		0.097	14092	6434	0.7	9.6
		LPD	0.395	-0.40	0.179		0.468	-4120	1851	3.3	-2.8
		PV	0.262	0.00	1.282		0.310	0	13215	2.2	0.0

SRR = Small, Rural, Residential; PIL = Program Involvement - Low; PIH = Program Involvement - High

BPA Program Review

BPA has been active in new construction for over 20 years. Incentives offered include several specific standard measures as well as a custom projects track.

Table 15 summarizes electric energy savings in new construction for the BPA utilities. Program savings of 2.1 aMW (average megawatts) were achieved in 2010. Following upon conversations with BPA staff, only the lighting and custom project measures are utilized with any significance; lighting measures represented 72% of savings, and the custom measures represented 28%.

Table 15. BPA Total New Construction Electric Savings

FY Completed October 1–September 31	Total Energy Savings @Busbar (aMW)	Number of Projects
2007	0.492	45
2008	1.219	118
2009	1.516	178
2010	2.100	106
2011 (completed through Aug. 15)	0.939	298
Total	**6.273**	**748**

BPA Lighting Incentive Program

The BPA lighting program provides standard incentives for each installed high-efficiency T8, high-output T8/T5 at greater than 15-foot heights, and ceramic metal halide luminaires. Incentives are also provided for occupancy sensor and timer lighting controls that are beyond code. Incentives are available only for projects that achieve 20% reduction in electric use beyond the assigned baseline. The savings can be achieved with any combination of the following fixtures and controls:

Deemed Lighting Measures

- High-performance T8 lamp and ballast system systems
- High-output high-bay fixtures (15-foot or higher mounting height) with two or more T5 lamps or three or more T8 lamps
- Occupancy sensor or timer controls with at least 100 watts of fluorescent lighting)
- Bi-level with OS stairwell or garage fixture
- Ceramic metal halide fixture
- LED down lights and wall packs
- Other one-time measures that are preapproved by BPA

Whereas incentives are calculated on a per fixture basis, lighting savings are calculated by the BPA C&I Lighting Calculator for each space described. The calculated base case lighting is determined from the specified space type and state. Lighting is assumed to operate for the number of hours specified, with no additional controls. The base LPD values are derived by the calculator based upon state and space type. In version 2.2 of the calculator, the Oregon code values are incorrect, with very high values in some categories and very low ones in others. In version 2.3, the code values for all states appear consistent with current energy code.

For the proposed case, the calculator assumes the fixtures entered for incentives in the calculator describe the whole proposed lighting system in a space. Non-incented lighting can be entered into a section titled "Non-Standard Lighting Measures," but there is no clear direction with respect to this. Fixtures not qualifying for incentives are possibly not entered into the calculator. If non-incented lighting is not entered, the lighting calculator will overestimate proposed case performance and savings.

The control savings calculation states that the controls must be above and beyond code, but there is no check for this. With the large number of lighting control provisions in each of the three regional codes, which change every three years, it seems likely that controls may in some cases be incentivized even though they are required by code.

The calculator also does not account for, or provide guidance for, how to treat successive controls. For example, the default savings of occupancy sensors are the same whether the base building has no control, or bi-level or automatic daylight control. Bi-level control has been required in Idaho and Montana since 2004. The default control savings value of 25% is used in all cases unless a higher value can be justified. In a warehouse OS control might save considerably less if daylight harvest is implemented, as would be required in OR and WA if skylights are installed. With the 25% OS control credit it would be possible to achieve the 20% savings requirement while the LPD was 5% over the baseline.

In the context of regional codes that require all buildings or only those over 5000 ft^2 to have time clocks or occupancy sensors, bi-level control (ID, MT, OR), and automatic daylight controls (OR, WA) the lighting calculation control credit needs to be significantly reworked. There should be specific instructions for when the credit may be claimed, and savings should be based upon some sort of characterization of the code-required controls.

Information available on lighting program projects is limited to the building type, savings, and rebate amounts. The lighting calculator spreadsheet is not archived, and there is no summary available of the LPD achieved, space types, baseline LPD assumption, or the project floor area. Without floor area or overall energy use, percentage savings and/or savings per square foot are not available.

The baseline control uncertainty, the lack of an explicit area to enter non-measure fixtures, and the outdated baseline in some building types makes understanding the lighting efficiency achieved by the current calculator an unknown. This does not mean that the program is not delivering savings of 20% or more, just that they are uncertain. It is recommended that:

- Final LPD, project area, controls credit, and calculator version number should be added to the tracking system.
- If the lighting calculator continues to be used, it should be audited and adjustments made to ensure the issues raised in the preceding discussion are addressed appropriately.
- The overall program structure does not provide an incentive to achieve more than the required 20% savings. Incentives decrease as the fixture count decreases. Some thought should be given to implementing some increased incentive per fixture as the savings percentage increases.

BPA Custom Projects Program
Custom projects cover a wide range of activities, from single measures such as heat pump installations to complex multi-measure packages with advanced chillers, windows, and shell. The program is available to new construction and major renovations. Total participation is limited to a small number of projects, peaking in 2009 with 23 projects. Staff members who were interviewed indicated that some custom projects apply separately for Lighting Incentives where that is advantageous.

Data available for these projects is limited to project title, building type, a one-line description, estimated and actual savings, and project cost. There are no floor area, detailed discussion of activities, or documentation of savings calculation procedure, assumptions, or the baseline used.

Comparison of BPA Lighting and Custom Programs with Next-Generation Codes
Comparing the current BPA new construction program offerings and savings with those from a next-generation codes incentive is difficult due to the lack of useful metrics, as described above. Total current program savings estimates are much larger than the savings estimated for next-generation energy codes. With the assumption that Washington's energy code improves by the same margin as the ID/MT code, next-generation code savings estimates approach the levels currently achieve by BPA. Even including predicted savings for all energy code changes over the last 16 years in addition to the next-generation code yields savings not quite twice the savings reported by the PTR system. Whether this speaks to the efficacy of current programs, population differences, or calculation differences is the issue in question.

Table 16. Annual Preference Energy Savings by State (2013–2022 Average)

State	Mandatory		Selected Increased-Efficiency Option	Mandatory Plus LPD Option			Avg. Annual New Floor Area (millions ft²)
	(kWh/ft²)	(aMW)		(kWh/ft²)	(aMW)	(% of Total Electric)	
ID/MT	0.653	0.070	LPD	1.123	0.120	7.0	0.93
OR	0.869	0.195	LPD	1.290	0.289	8.9	1.95
WA	-0.238	-0.383	LPD	0.162	0.260	1.3	13.99
Total	-0.061	-0.118	LPD	0.347	0.669	2.5	16.87
Alt. Total[1]	0.679	1.308	LPD	1.144	2.202	7.2	16.87

1 – Assumes Washington code improves by same amount as the ID/MT code

Population differences certainly account for part of the difference. The next-generation code analysis is limited to forecasted new floor area and does not include impacts on remodeled floor area. Some, but not all, of these are situations in which next-generation energy codes would have impact and therefore represent undercounting of the savings attributed to future codes. However, many of these are situations in which the energy code might not be triggered as well as situations in which a next-generation code incentive might be difficult to administer due to the smaller project scope or scale, which would make demonstrating code compliance relatively time-consuming. BPA programs are not particularly limited to new construction and include many projects involving remodel and renovation, or even just equipment replacement work.

Calculation and baseline differences also play a role in this comparison. The next-generation codes analysis uses the current 2011 energy codes as the calculation baseline. The baseline used in the BPA lighting calculator and the custom projects reflects some unknown condition. For most projects reported, the base case condition is prior to the current energy codes, some of which became effective only in 2011.

A second calculation factor is that this evaluation estimates energy savings from a different baseline than the calculator. The next-generation code savings estimates do not claim savings for current saturations of controls found in the 2002–2004 NEEA New Construction Survey, and lighting power savings are calculated as a proportional change from the NEEA New Construction Survey installed wattage, which effectively assumes that the base case condition is somewhat better than the base code. Another calculation issue is that lighting calculator deficiencies with respect to controls, as well as base LPD, could be inflating reported energy savings.

Program efficacy is also likely a factor in that the current BPA programs can incentivize savings beyond next-generation code levels when projects are willing, whereas the next-generation code incentive is limited to the future code level. Whether the increased appeal or accessibility of a next-generation code program would offset this is difficult to assess.

It is therefore very difficult to draw conclusions comparing the next-generation code savings with BPA estimates of program savings.

Another perspective is to compare the basic technology and lighting power densities. The technology increment represented by currently incentivized fixtures is the same set of technologies assumed to establish the IECC 2012, Oregon 2010, and Washington 2010 lighting codes.

The lighting program requirement that projects save 20% over baseline means that if the baseline lighting calculator LPD values reflected current codes, the 20% requirement could be compared to the change brought by next-generation code lighting requirements. Table 17 shows the estimated NEEA New Construction Survey inventory average code LPD for the next-generation codes. This is a code-to-code comparison similar to the lighting calculator. The next-generation codes fall short of the 20% minimum savings targeted by the lighting calculator. However, with the high-efficiency lighting option included, next-generation code savings approach the 20% program goal, except in Washington.

Table 17. Average LPD Inputs by State Code (W/ft²). NEEA New Construction Survey[1]

State	Average Code Required LPD (W/ft²)			Percent Reduction	
	Base Code	Next-Generation Code	Next-Generation Code High-Eff. Option	Next-Generation Code	Next-Generation Code High-Eff. Option
ID/MT	1.15	1.07	0.92	7.0%	20.0%
OR	1.06	1.00	0.90	5.7%	15.1%
WA	1.02	1.07	0.92	-4.9%	9.8%

1 – Average LPD for all building in baseline study

2 – Proportional shift would be larger than this. Value modeled was limited by the calculation framework. Given the very small savings in Washington, this was not corrected. If the Washington lighting increment becomes an important consideration, the framework should be rebuilt to handle this case better.

In version 2.3 of the BPA lighting calculator, the lighting power density has been updated so the baseline reflects current code maximum LPD requirements. If the calculator is further updated to better account for the overall code allowance calculation, the requirement to exceed code by 20% provides much of the same minimum lighting savings that next-generation codes offer with the lighting increased-efficiency option. The lighting calculator has the added flexibility of counting savings beyond 20%, though the incentive structure offers a disincentive to decreasing LPD by more than 20%. The calculator also offers an easy compliance path for new small and remodel/renovation projects to achieve the most significant portion of available electric savings.

While the lighting calculator can deliver similar lighting energy savings as next-generation codes, other aspects of building efficiency must utilize the custom project path to achieve savings that next-generation codes will impact. It is recommended that consideration be given to developing incentives based upon project-specific code compliance modeling. This would provide an easy path to achieve savings from other aspects of the building and also provide a way of incentivizing lighting savings beyond 20%. Performance path (modeling) options are expanded in the 2012 IECC and Oregon Reach. The Oregon Reach requires buildings over 70,000 ft² to use the performance path. If a modeling-based incentive program could be developed, it could be used in general outline in all states. It also would provide a means of offering incentives for performance beyond next-generation code compliance. Since performance path code compliance is fuel blind, program criteria would need to go beyond mere code compliance and require documentation of electric savings.

If the lighting incentive drops the better-than-code requirement and focuses only on specific lighting technologies, then a special review of the technologies assumed by the program should be conducted. To ensure real energy savings, the lighting technology requirements should be extended beyond lamp and ballast assumptions to include fixture efficiency as well.

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Appendix A. Oregon Reach Overview

The Oregon Reach Code (ORC) is an adjunct to the existing 2010 OEESC and describes several high-performance paths above the current code. At the most basic level, a project must comply with many sections of the 2010 OEESC, a number of mandatory provisions in the Reach Code, and must choose three high-performance options. The options have the result that energy savings can come from different areas and fuels and even include some items such as recycled content that do not directly save energy. The code also places an emphasis on modeling by requiring all projects over 70,000 ft^2 and some projects over 50,000 ft^2 to demonstrate compliance through modeling. The referenced methods utilize energy cost as the measure of energy use.

Table 1. Oregon Reach Code Compliance Options

Path	Description	Projects Qualifying for Path / Comments
Prescriptive	Must meet all mandatory sections of prescriptive path including metering, envelope, HVAC, lighting, and commissioning, and choose one high-efficiency option and two "mandatory electives."	Limited to all buildings with total area <=50,000 ft^2 or those with total area <=70,000 ft^2 with simple mechanical systems. OEESC 2010 defines simple systems as "unitary or packaged HVAC equipment listed in Tables 503.2.3 (1) through 503.2.3 (5), each serving one zone and controlled by a single thermostat in the zone served. It also applies to two-pipe heating systems serving one or more zones, where no cooling system is installed." Total building area not defined but might mean a 1000 ft^2 addition to a 71,000 ft^2 building needs to pass via the performance path.
Performance	Must meet all mandatory sections of performance path including metering, lighting, and commissioning and then demonstrate that the design has 18% less "energy use" than a baseline building including the 2010 OEESC and Reach Mandatory provisions, or uses 26% less energy than the 90.1 - 2007 Appendix G baseline. The project must also select two "mandatory electives."	Available to all projects. Differential savings requirement between modeling approaches implies 2010 OSEC with the reach mandatory provisions is 8% more efficient than ASHRAE 2007 as determined by Appendix G. This assumes that the App. G and 2010 OEESC methods are comparable, which is not a given, with the App. G process likely yielding higher savings in most cases. Any differential would have to be accounted for in this comparison. Both methods are energy cost methods, meaning the energy source saved is not distinguished.

The varied compliance paths present a challenge to designing an electric energy incentive program around the code, as the quantity and type of energy savings are variable. An incentive could be based upon a particular prescriptive path or particular components of the prescriptive path, which would allow some assurance of electric savings. Based upon the NEEA New Construction Baseline data, a majority of projects in the BPA Oregon service territory (representing half the floor area) are at least eligible for the prescriptive path. To utilize a program keyed on the prescriptive path, projects following the performance path would have to comply with the specified components of the prescriptive path as well to gain an incentive. In many cases this would not be a hardship, but it would mean that projects would not benefit from the perceived flexibility of the performance method.

Serious consideration should be given to offering incentives as determined by code compliance modeling. If a modeling-based incentive program could be developed, it could be used in general outline in all states. It also would provide a means of offering incentives for performance beyond future code compliance. Since performance path code compliance is fuel blind, program criteria would need to go beyond mere code compliance and require documentation of electric savings beyond a certain point. A fairly simple report could be designed to highlight a project's electric savings. Because the current allowed modeling

approaches are fairly flexible, allowing for considerable creativity, and possibly give credit for typical performance in areas not addressed by the code, some sort of de-rating of savings should occur to account for the quantification method. This would be in addition to any realization rates related to adjusting savings for standard practice.

For Oregon Reach, designing an incentive program based on performance path electric savings is complicated by having two allowed modeling approaches, one whose base code is ASHRAE 90.1 - 2007 Appendix G. The de-rating of electric savings will need to be developed for each performance path method. It will need to account for the realization rate for model predicted savings of the different modeling method, account for any differences in the base code and the model base, and provide cover for any other concerns that modeling might not reflect actual energy savings. Appendix G has some specific issues in this area.

Prescriptive Path

The ORC prescriptive path is summarized in Table 2. The base mandatory requirements include a 10% to 20% reduction in maximum component conductance from the OEESC, approximately 10% lower lighting power allowance, commissioning (light for <50,000 ft^2, full for larger buildings), and end use metering and automated demand response for larger buildings. The mandatory prescriptive requirements are very comparable to ASHRAE 90.1 - 2010 values except the ORC envelope values are better, particularly west of the Cascades.

One "increased building efficiency" option must be implemented from the following list:

- LPD 10% less than ORC mandatory lighting (609.1).
- Renewables with rated capacity of 1.75 BTU/ft^2 or 0.5 W/ft^2 or >3% of building mechanical, water, and lighting energy use. The compliance issue is somewhat unresolved. ORC specifies modeling to estimate energy use but is silent on load factor. Assuming a mid-range factor, then the required PV installation would be around 0.25 W/ft^2 for office, retail, schools, and warehouse. Hospital, restaurant, and grocery would be higher and therefore would utilize the base 0.5 W/ft^2 requirement.
- Increased mechanical efficiency. Table value (607.2.4) or if not listed 10% better than federal standards. Equipment not regulated (electric resistance, gas-fired radiant, VRF) are not required to improve.

In addition, two project electives are required and must be chosen from the list presented in Table 3. For the prescriptive path, the electives noted as "simulation" are unlikely to be utilized.

For evaluating code energy savings, the base prescriptive mandatory requirements can be treated as one package and then each "increased building efficiency" option and the additional project electives with direct energy savings modeled as measures. This will provide a menu of measures and savings from which a program can be specified. A detailed listing of the code requirement changes between the 2012 OEESC and the ORC is presented as an appendix.

Performance Path

While the performance path will not be evaluated in this work, the compliance path is worth characterizing. The base mandatory requirements are significantly reduced from the prescriptive path. The base mandatory requirements include air sealing/air barrier/air leak testing, an approximate 10% reduction in lighting power allowance, commissioning (light for <50,000 ft^2, full for larger buildings), and end use metering and automated demand response for larger buildings. There are no mandatory requirements for envelope conductance or mechanical equipment efficiency, and no increased building efficiency option requirement. Performance projects must select two project electives from Table 3.

Compliance is established by meeting all performance path mandatory sections and having a building energy model that demonstrates the design complies. Using the OEESC whole building approach (WBA) the proposed building modeled energy use must be 18% less than the reference building, which includes the 2010 OEESC and Reach performance path mandatory provisions. In addition, two project electives from Table 3 must be implemented. Alternatively the ASHRAE 90.1 - 2007 Appendix G approach can be used. The proposed building energy use must be 26% less than the 90.1 - 2007 Appendix G baseline, and it must be third-party certified (LEED) or include two project electives from Table 3. Both approaches are energy cost methods, meaning the energy source saved is not distinguished. The WBA specifies the energy costs to be used. ASHRAE 90.1 - Appendix G uses either the actual utility rates or state averages as summarized by the IEA.

Table 2. Reach Prescriptive Path Mandatory Requirements

Aspect	Section #	Description
Envelope	OEESC 502	All OEESC Envelope Requirements
	606	Reach Envelope Systems including upgraded opaque and window requirements, fixed shades required on buildings with WWR >20%, air leakage testing for buildings >20,000 ft^2 (0.25 cfm/ft^2), and minimum skylight area for enclosed spaces >10,000 ft^2 (auto control of day lit zones already in OEESC).
Mechanical	OEESC 503	All OEESC Mechanical Requirements
	607	Reach Building Mechanical Systems. Tighter high pressure ducts, VAV VFD to 1 HP (from 10 HP), hotel/motel guest room control. Main change is requirement for one increased building efficiency option from this list: • LPD 10% less than reach code lighting (609.1) • Renewables with rated capacity of 1.75 BTU/ft^2 or 0.5 W/ft^2 • Renewables with rated capacity >3% of building mechanical, water, and lighting energy use • Increased mechanical efficiency. Table value (607.2.4) or if not listed 10% better than federal standards
Service Water	OEESC 504	Service Water Heating
	608	Building Service Water Heating Systems. Little changed from OEESC except plumbing, electrical and controls must be designed to provide for future installation of solar hot water, and laundries shall have waste water ER to preheat all incoming water used for hot water functions by not less than 10°F.
Lighting/ Electrical	OEESC 505	Electrical Power and Lighting Systems
	609	Building Electrical Power and Lighting Systems. New whole building LPD requirements ~10% better but space-by-space values essentially unchanged, OS control in storage and stack areas, plug load controls in private offices and computer classrooms (or OS plug strips), and extra transformer efficiency.
Other	604	Energy Metering, Monitoring and Reporting. Sec 604 requires building metering of each fuel and also circuiting/plumbing that separates end uses (HVAC, lighting, plug, and process). Requires end-use sub-metering in buildings >70,000 ft^2.
	605	Automated Demand Response (Auto-DR) Infrastructure. Section 605 requires EMCS for lighting and HVAC with Auto-DR relays and programming. Exempted buildings include: buildings <50,000 ft^2, buildings with peak energy <=0.5 times the "standard reference design," and buildings with on-site renewables providing 20% or more of building's energy demand.
	610	Specific Appliances and Equipment. Sets efficiency requirements for elevators, escalators, commercial food service equipment, and conveyors.
	611	Building Renewable Energy Systems. All buildings (prescriptive only?) must be designed with space, clearances, and structure to accommodate at least one renewable system capable of producing 2% of total calculated (performance) or estimated (prescriptive) energy use. For prescriptive, minimum renewables design must provide 1.75 Btu/hr or 0.5 W/ ft^2.
	612	Energy Systems Commissioning and Completion. Must provide evidence of mechanical system functional performance testing. Must be TABed and have preliminary acceptance report. And drawings and manuals must have data about installed equipment and test procedures. Buildings >50,000 ft^2 must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics, and control sequences for HVAC, lighting, DHW, and renewable system.

Table 3. Reach Project Electives

Third Party Certification (counts as two electives)	Notes
Certification with model showing 26% savings over 90.1 - 2007 App. G baseline.	Simulation. Equates third-party certification to extra 12% energy savings.
Energy Electives	
Model showing 25% over 2010 OEESC or 33% 90.1 - 2007 App. G baseline.	Simulation
Model showing 30% over 2010 OEESC or 38% 90.1 - 2007 App. G baseline.	Simulation
Mechanical Equipment Efficiency Improvement. Table 607.2.4 efficiency or 10% better for unlisted equipment.	Not available to prescriptive projects that select Increased Mechanical Efficiency as their increased-efficiency option in Section 607.1.1.
Service Water Heating Equipment Improvement. 10% better than 2010 OEESC requirements.	Available only for high water users: restaurants, laundries, lodging, R-2, health clubs, hospitals, nursing homes.
Lighting system efficiency. Interior and exterior LPD must be 10% less than Reach 609.1.	Prescriptive projects that select Lighting Power Density Improvement as their increased-efficiency option in Section 607.1.1 must exceed 607.1.1.1 lighting levels by 10%. (~20% better than 609.1)
Building thermal envelope system (Must exceed values of Reach prescriptive envelope by at least 10%.)	
Passive design (613.7). Simulation must document that >40% of the annual energy use reduction realized by the *proposed design has* been achieved through passive heating, cooling, and ventilation design, as compared to the *standard reference design*. Passive heating and cooling shall use strategies including, but not limited to, *building* orientation, fenestration provisions, material selection, insulation choices, overhangs, shading means, microclimate vegetation and water use, passive cooling towers, natural heat storage, natural *ventilation,* and thermal mass.	Simulation. Not clear this is "additional energy savings" or just seeking a certain type of savings.
Post Occupancy Commissioning	Extensive requirements. In complex buildings this could lead to big savings in some percentage of cases. In box retail, warehouse, or small buildings this likely does not save significant energy.
Project Renewables of 1.75 BTU/ft^2; or 0.5 W/ft^2; or >2% of building mechanical, water, and lighting use. If Sec 607.1.1.2 increased-efficiency option is used, then this elective must be >4% of building mechanical, water, and lighting use.	Assuming mid-range load factor, then the required PV installation would be around 0.2 W/ft^2 for office, retail, schools, and warehouse. Hospital, restaurant, and grocery would be higher and therefore would utilize the base 0.5 h^2 requirement.
Non-Energy Electives (energy is indirectly saved)	
Roof covering - vegetative roofs (404.3 & 405.6)	
Waste management - 50% diversion or 20% better than jurisdictional requirements (508.2)	
Reused, recycled content (55%) (503.1)	
Daylighting (808.1). Requires 50% or more of the floor area to be in day lit zones. The OEESC requires daylight harvest in many situations, and this will provide daylight control zones.	Indirect energy measure. OEESC already requires skylights in spaces >10,000 ft^2.
Water - four points that reference nonexistent sections	
710.2 & 3 - Appliances	List is missing so uncertain how much this might impact energy use.
710.5 Non-potable water for flushing	
710.8 Non-potable water for industrial makeup water	
710.11 Gray water collection	

Table 4. Reach Performance Path Mandatory Requirements

Aspect	Section #	Description	Notes
Envelope	606.1.2	Air leakage. Sealing language and air barrier required. Buildings larger than 20,000 ft^2must be tested and have leakage <0.25 cfm/ft^2 at 75Pa.	No model credit. Must be in reference building.
	606.1.3	Minimum Skylight Area. In enclosed spaces >10,000 ft^2 with ceiling height >15 ft with LPD <0.5 W/ft^2 and used for most purposes and under roof, must have 50% of area in daylight zone with a minimum of 3% skylights, and the skylights must have VLT >0.4. Skylights must not be >5% of gross roof.	No model credit. Must be in reference building.
Mechanical	OEESC 503.2	Mechanical System general requirements.	
	607.3	Ventilation. Must be capable of reducing OA to OMSC chapter 4 or ASHRAE 62.1, sec 6.3 minimums. Also requires ERV if ventilation exceeds minimums of OMSC or 62.1 (no specifics on which section).	No model credit. Must be in reference building.
Service Water	OEESC 504	Service Water Heating	
	608	Building Service Water Heating Systems. Little changed from OEESC. Plumbing, electrical and controls must be designed to provide for future installation of solar hot water. Laundries shall have waste water ER to preheat all incoming water used for hot water functions by not less than 10°F.	No model credit. Must be in reference building.
Lighting/ Electrical	OEESC 505	Electrical Power and Lighting Systems	
	609	Building Electrical Power and Lighting Systems. New LPD requirements ~10% better, OS control in storage and stack areas, plug load controls in private offices and computer classrooms (or OS plug strips), and extra transformer efficiency.	No model credit for plug load controls. Must be in reference building.
Other	604	Energy Metering, Monitoring, and Reporting. Sec 604 requires building metering of each fuel and also circuiting/plumbing that separates end uses (HVAC, lighting, plug, and process). Requires end-use sub-metering in buildings >70,000 ft^2.	
	605	Automated Demand Response (Auto-DR) Infrastructure. Section 605 requires EMCS for lighting and HVAC with Auto-DR relays and programming. Exempted buildings include: buildings <50,000 ft^2, buildings with peak energy <=0.5 times the "standard reference design," and buildings with on-site renewable providing 20% or more of the building energy demand.	
	610	Specific Appliances and Equipment. Sets efficiency requirements for elevators, escalators, commercial food service equipment, and conveyors.	
	612	Energy Systems Commissioning and Completion. Must provide evidence of mechanical system functional performance testing. Must be TABed and have preliminary acceptance report. And drawings and manuals must have data about installed equipment and test procedures. Buildings >50,000 ft^2 must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics, and control sequences for HVAC, lighting, DHW, and renewable system.	

Appendix B. 2012 IECC Overview

The 2012 International Energy Conservation Code (IECC) is an incremental update of the 2009 IECC and, unlike the Oregon Reach code, is a stand-alone code. It has a mix of mandatory provisions, a list of increased-efficiency options from which one must be chosen, and a performance path that allows more flexibility. The prescriptive and performance paths are available to all buildings, and buildings also have the option of utilizing the ASHRAE 90.1 - 2010 prescriptive or ECB compliance paths.

The varied compliance paths present a challenge to designing an electric energy incentive program around the code, as the quantity and type of energy savings are variable. An incentive could be based upon a particular prescriptive path to allow some assurance of electric savings. Addressing the performance compliance path directly presents an opportunity for BPA. If a modeling-based incentive program could be developed, it could be used in all states and possibly be implemented in the same format in all states. This is currently beyond the scope of this project, but serious consideration should be given to offering incentives for advanced performance as determined by modeling.

For the current purposes, only the IECC prescriptive and performance paths will be discussed. The optional use of ASHRAE 90.1 is not evaluated, though its presence represents a weakening of the code in that buildings not complying with the IECC can attempt to comply with the 90.1 instead.

Prescriptive Path

The 2012 IECC prescriptive path mandatory requirements include slight improvements to lighting, opaque envelope, and equipment requirements over the IECC 2009. It has significant improvements to the window conductance, building air leakage, and boiler requirements. It also requires commissioning of buildings with more than 40 tons cooling capacity or 60 tons heating capacity.

Beyond the mandatory requirements, one increased-efficiency package must be implemented from the following list:

- Mechanical system improvement. Tables C406.2 presents new values. Option is stated in the code to not be available if C406.2 performance is not better than the C403.2 requirements. Correspondence with ICC staff indicates that if the equipment is listed, then for most cases it qualifies. Also, non-regulated equipment (electric resistance, gas fired infrared, VRF) is not required to be improved. If a building is electric resistance with one PTAC unit, as long as the PTAC unit meets C406.2 requirements, then the building qualifies as meeting the extra mechanical efficiency path.
- Lighting system efficiency as provided in Section and Table C406.3. (values are ~0% to 20% better than 2009 IECC)
- Renewables of 1.75 BTU/ft^2 or 0.5 W/ft^2 or >3% of building mechanical, water, and lighting use. The later 3% requirement leaves the compliance issue of how to establish this completely unresolved. Assuming model results would be accepted, then the required PV installation would be around 0.25 W/ft^2 for office, retail, schools, and warehouse. Hospital, restaurant, and grocery would be higher and therefore would utilize the base 0.5 W/ft^2 requirement.

The prescriptive mandatory requirements with the optional high-efficiency lighting requirements are very comparable to ASHRAE 90.1 - 2010 values except for the envelope values, which exceed 90.1, particularly west of the Cascades. The renewables and mechanical system options would leave light levels well below ASHRAE 90.1 requirements but offset some or all of that energy through renewables or high-efficiency heating and cooling equipment.
For evaluating code energy savings, the base prescriptive mandatory requirements can be treated as one package and then each "increased building efficiency" option modeled as a measure. This will provide a

menu of measures and savings from which a program can be specified. A detailed listing of the code requirement changes between the 2009 IECC and the 2012 IECC is presented as an appendix.

Performance Path

The IECC performance path mandatory requirements are limited to air leakage and sealing, mechanical system general requirements, service water, lighting, and commissioning. It allows buildings to forgo the envelope efficiency, the mechanical simple and complex system requirements, and the additional efficiency package. In trade modeling must show a 15% improvement over the reference building, which includes the envelope and most other mandatory requirements.

A brief review raised some concerns about whether the standard reference design was held to the same standard as the prescriptive path. Many provisions of the complex mechanical path do not appear to be required in base building (service water HR, VAV VFD threshold 20 HP rather than 7.5).

Washington State

The State of Washington has passed legislation requiring the next code to be based upon the 2012 IECC. Many stakeholders will propose significant amendments to the base code similar to the Oregon amendments to the 2009 IECC. Other stakeholders will argue for adopting the 2012 IECC unchanged. The actual outcome is very uncertain, but the starting point is the 2012 IECC.

Determining energy savings between the IECC 2012 and the 2009 WSEC is extremely difficult. Typically code changes step towards more efficiency with very few provisions being relaxed. With the changing code bases, the incremental improvements are accompanied by the decrement of others. For the primary LPD, building envelope, and equipment efficiency requirements the two codes are not dramatically different, though it appears the 2012 IECC is an improvement. There are also several other items currently regulated by the 2009 WSEC that are not regulated in the IECC 2012.

A qualitative comparison between the prescriptive paths of the 2012 IECC and the 2009 WSEC prescriptive paths is made in this work, and a detailed listed of the differences is listed in Appendix C. At this point, the likely energy savings appear to be small and likely unsuitable for the basis of a program.

Table 5. 2012 IECC Compliance Options

Path	Description	Comments
Prescriptive	Must meet all mandatory sections of prescriptive path including envelope, HVAC, lighting, service water, and commissioning, and choose one high-efficiency package. Packages include HVAC per C406.2, lighting per Section C406.3, or installing renewables per C406.4.	
Performance	Must meet all mandatory sections of performance path including HVAC general provision, lighting, service water, and commissioning, plus show modeled energy use (cost basis) 85% or less of baseline per C407. Procedure is hybrid approach between ASHRAE 90.1 ECB and Appendix G with IECC2012 requirements used in the base case (in most cases).	Mechanical simple and complex sections are not mandatory, and some of the controls requirements are not reflected in the base case systems. Examples include service water HR, VAV VFD threshold of 20 HP rather than complex path 7.5 HP, and 40% glazing fraction, perhaps with daylight control but not clear.
ASHRAE 90.1 2010	Buildings can demonstration compliance via ASHRAE 90.1 prescriptive or ECB.	Having multiple paths allows projects to pick and choose the method that treats their building the kindest and represents a general, hard to quantify weakening of the code. In most cases the ASHRAE 2010 envelope is not nearly as good as the IECC 2012, the light levels are equivalent to the IECC High-efficiency Lighting path, and controls are more advanced. A high glazing building would likely utilize 90.1, while most others would likely choose IECC 2012.

Table 6. 2012 IECC Prescriptive Path Mandatory Requirements

Aspect	Section #	Description of Added Provisions	Notes
Envelope	C402	Building Envelope Systems. Upgraded opaque insulation and u-values. More insulation required for most roofs, walls, and slab floors.	
	C402.2	Upgraded opaque insulation and u-values	Values better than 2009 IECC. A step backwards from 2009 WSEC except for large improvement in mass walls.
	C402.3	Upgraded window u-values. Reduced glass from 40% to 30% unless 50% of floor area is in daylight zones with automatic controls. Increased allowable skylight from 3% to 5% if automatic daylight controls.	New for IECC, similar to 2009 WSEC.
	C402.3.2	Minimum skylight for zone 5 spaces >10,000 ft^2 under roofs with LPD >0.5 W/ft^2.	New for IECC and WSEC.
	C402.4	Air leakage. Sealing language and air barrier required. Buildings can comply by using tested low-leakage materials, assembles, or be tested and have leakage <0.40 cfm/ft^2 at 75 Pa.	New for IECC, similar to 2009 WSEC.
HVAC	C403	Building Mechanical Systems	
	C403.2	General requirements. Sizing, equipment efficiency.	Very similar to 2009 IECC, and 2009 WSEC
	C403.3	Simple Path requirements	
	C403.4	Complex Path Requirements	Many upgrades.
Service Water	C404	Building Service Water Heating Systems.	No big changes.
Lighting	C405	Building Electrical Power and Lighting Systems	Base LPD levels very similar to 2009 IECC and less than the 2009 WSEC.
Other	C406	Additional Efficiency Package Option. Building must have one of the following: increased mechanical efficiency per C406.2 (not available if C406.2 equipment efficiency is not higher than C403.2 value; LPD per 406.3 (~0% to 20% less than 405) with automatic daylight controls and skylights required in warehouse; Renewables of 1.75 BTU/ft^2 or 0.5 W/ft^2; renewables of >3% of building mechanical, water, and lighting use.	C406.3 LPD levels are better than base 2012 values and 2009 WSEC values.
	C408	Energy Systems Commissioning and Completion. Buildings with >40 tons cooling or >60 tons heating must provide evidence of mechanical system functional performance testing. Must be TABed and have preliminary acceptance report. Drawings and manuals must have data about installed equipment and test procedures. Must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics and control sequences for HVAC system.	New for IECC, similar to 2009 WSEC.

Table 7. 2012 IECC Performance Path Mandatory Requirements

Aspect	Section #	Description	Notes
Envelope	C402.4	Air leakage. Sealing language & air barrier required. Buildings can comply by using tested low leakage materials, assembles or be tested and have leakage <0.40 cfm/ft^2 at 75 Pa.	
Mechanical	C403.2	Mechanical general requirements. Sizing and equipment efficiency.	
Service Water	C404	Building Service Water Heating Systems	
Lighting	C405	Building Electrical Power and Lighting Systems	
Other	C408	Energy Systems Commissioning and Completion. Buildings with >40 tons cooling or 60 tons heating must provide evidence of mechanical system functional performance testing. Must be TABed and have preliminary acceptance report. Drawings and manuals must have data about installed equipment and test procedures. Must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics, and control sequences for HVAC system.	

Appendix C. Measure Evaluation Details

Envelope Insulation

The 2012 IECC and Oregon Reach codes require the thermal integrity to improve for most building envelope opaque and fenestration components. In Washington the changes are mixed with some values improved (mass walls), but most requirements are reduced.

The 2012 IECC also reduces the maximum allowed fenestration to 30% of gross wall area (the 2010 OEESC already has this limit). It is assumed in this analysis that high glazing buildings will not change the amount of glass, but rather opt to install better windows and improved thermal performance of other aspects of the envelop. Some will opt for less glass, but at least the thermal impact is similar on the first order. There is a cost impact, as moving from glass to wall has a cost very different from that of moving from good to excellent windows.

Savings from envelope code changes were estimated by simulating the regional prototypes with envelope characteristics derived from the NEEA New Construction Survey data. For each NEEA New Construction Survey building, audit shell data was used with the current and future codes to calculate the whole building heat loss rate per square foot for the as-found building, and for the current future code. From the code values, the whole building heat loss rate per square foot consistent with the proportional shift scenario was calculated for each code, and the difference between the proportional values averaged by building type. This average change in heat loss per square foot was modeled in the prototype.

For each state and climate zone code change, the code and scenario values were determined by applying the current and future energy codes for that state and climate zone to *all* buildings audited in the NEEA New Construction Survey rather than limiting the sample to the buildings found in the given state. Using all regional buildings rather than just those occurring in a particular state was necessary due to the small sample sizes for individual building types within each state and climate zone. A side benefit is that the code heat loss per square foot can be directly compared, since the building set is the same for each code. The table below summarizes the increments for each state.

Table 18 presents the results of the proportional shift scenario by state and climate zone. The average was not modeled directly. Rather, prototype insulation values of the modeled prototype were adjusted to achieve the target heat loss rates.

Table 18. Envelope Data Summary by State (UA/ft²). NEEA New Construction Survey

State	Zone	Code Heat loss Rate (UA/ft²)		Modeled ΔUA[1] (UA/ft²)
		Current Code	Future Code	
ID	5	0.154	0.135	-0.015
ID, MT	6	0.147	0.128	-0.016
OR	OR	0.164	0.129	-0.030
WA	State Zone 1 to IECC 4/5	0.154	0.135	-0.016
WA	State Zone 2 to IECC 5	0.147	0.135	-0.011

[1] The average of the individual proportional ΔUAs differs from the proportional ΔUA calculated from the average heat loss rates.

Cost Estimate

Envelope cost data was developed primarily from material produced by the Woolzee Company. Component level costs were applied to the NEEA New Construction Survey building inventory and summed to arrive at a total cost per unit floor area for the envelope provisions of the code. Table 19 presents the cost for various envelope component changes. Table 20 contains cost data for fenestration increments.

Table 19. Opaque Envelope Costs ($/ft²).

Comp.	Item	Code	Increment	Cost ($/ft²)	Notes[1]
Door	Roll-up/ Sliding	IECC	U0.50 to R4.75	1.58	WZ: Insulated door cost - $1.35/ft²
		ORCH	No change	0.00	No change
		WSEC	U0.60 to R4.75	1.58	WZ: Insulated door cost - $1.35/ft²
Door	Swing	IECC	U0.70 to U0.37	1.05	WZ: Door Cost $0.90/ft²
		ORCH	U0.70 to U0.50	0.88	WZ: Door Cost $0.75/ft²
		WSEC	U0.60 to U0.37	1.05	Use WZ U0.7 to U0.37 cost
Floor	Joist	IECC	no change	—	No change
		ORCH	R30/U0.033 to R38/U0.027	0.41	WZ: $0.35/SF insulation
		WSEC	steel - R38+R4/U0.029 to R30/U0.033		Assumed no change.
		WSEC	wood - R30/U0.029 to R30/U0.033	—	No change based upon insulation
Floor	Mass	IECC	no change	—	No change
		ORCH	R10/U0.074 to R14.6/U0.057	0.76	WZ: $0.65/SF added spray-on
		WSEC	R30/U0.029 to R10/U0.074	-3.04	Use WZ spray on cost of $0.65 for one lift. Assume R5 per lift, 4 lifts for R20.
Floor	Slab	IECC z4m/5	R0/F0.73 to R10/F0.54	1.99	WZ: $1.70/LF insulation + install
		IECC z6	No change	—	No change
		ORCH	2'R10/F0.54 to 2'R15/F0.528	1.11	WZ: $0.95/LF insulation. No labor.
		WSEC	No change	—	No change
Floor	Slab, Heated	IECC	2'R15/F0.86 to 3'R15/F0.58	2.57	WZ: $2.2/LF insulation + added installation
		ORCH	2'R15/F0.86 to 4'R15/F0.688	4.62	WZ: $3.95/LF insulation + added installation
		WSEC	R10ci/F0.36 to 3'R15/F0.58	—	No heated slabs reported in NEEA New Construction Survey so cost not developed

Comp.	Item	Code	Increment	Cost ($/ft²)	Notes[1]
Roof	Attic/ Other	IECC z4m/5	No change	—	No change
		IECC z6	R38/U0.027 to R49/U0.021	0.47	WZ: $0.40/SF - assumed batt insulation
		ORCH	R38/U0.027 to R49/U0.021	0.47	WZ: $0.40/SF: Assumed loose fill insulation
		WSEC	No change	0.00	No change
Roof	Metal Bldg	IECC z4m/5	R13+13/U0.055 to R19+R11LS/U0.035	0.70	WZ: Added $0.60/SF for material and installation
		IECC z6	R13+19/U0.049 to R25+R11LS/U0.031	0.94	WZ: Added $0.80/SF for material and installation
		ORCH	R13+13/U0.055 to R19+11LS/U0.035	0.29	WZ: $0.25/SF material and installation
		WSEC	R25+R11LS/U0.031 to R19+R11LS/U0.035	-0.53	WZ: $0.45/SF for R13+19 to R25+R11LS
Roof	Roof deck	IECC z4m/5	R20/U0.048 to R25/U0.039	0.23	WZ: Added $0.20/SF for material and installation
		IECC z6	R20/U0.048 to R30/U0.032	0.47	WZ: Added $0.40/SF for material and installation
		ORCH	R20/U0.048 to R30/U0.032	0.47	WZ: Added $0.40/SF for material and insulation
		WSEC	R30/U0.034 to R25/U0.039	-0.23	WZ: Subtracted $0.20/SF for material and insulation
Skylight		IECC	U0.6 to U 0.5, but if autodaylight harvest then U0.75 allowed.	0.0	If skylight without harvest then cost is $3.35/ft² (Ecotope cost from 2009 WSEC evaluation: CostsEnvel_lights 2009.xls.). But if daylighting then cost negative. No cost assumed.
		ORCH	No change	—	No change
		WSEC	With curb, U0.6 to U 0.5, but if auto daylight harvest then U0.75 allowed in 2012 IECC.	0.0	No cost assumed. See IECC discussion.
		WSEC	Without curb, U0.5 to U 0.5, but if auto daylight harvest then U0.75 allowed in 2012 IECC. Could be negative cost.	—	No change
Wall	Below Grade	IECC 4m/5	No change	—	No change
		IECC z6	No change	—	No change
		WSEC z1	R5.7/U0.15 to R13.3/U0.078	—	same as above grade mass wall
		WSEC z2	R7.6/U0.123 to R13.3/U0.078	—	same as above grade mass wall
Wall	CMU	ORCH	Corefill to R11.4/U0.09	2.808	WZ: $4.10 from unfinished to wood frame, $2.80 from finished cmu to wood frame, $2.00 for unfinished to clip sys, $0.7 from finished cmu to clip. Assumed average of $2.4/sf.
		WSEC z1	Corefill to R13.3/U0.078	2.808	WZ: $4.10 from unfinished to wood frame, $2.80 from finished cmu to wood frame, $2.00 for unfinished to clip sys, $0.7 from finished cmu to clip. Assumed average of $2.4/sf.
		WSEC z2	R7.6/U0.123 to R13.3/U0.078	0.75	from R8 z-metal strip to R11.4 rigid, or metal clips with r13.3. Metal stud indicated as not possible unless some rigid added. Could do it with R13 wood.

Comp.	Item	Code	Increment	Cost ($/ft²)	Notes[1]
Wall	Mass	IECC z4m/5	R11.4/U0.09 to R11.4/U0.078	—	No change
		IECC z6	R13.3/U0.08 to R13.3/U0.078	—	No change
		ORCH	R11.4/U0.15 to R11.4/U0.09	1.053	WZ: $0.90 for added R4. Metal stud indicated as not possible unless some rigid added (R11+5ci). Could do it with R11 wood frame.
		WSEC z1	R5.7/U0.15 to R13.3/U0.078	1.086	same as 4c by U, and in ashrae tables R11.4 goes with U0.078. But if going by R need R11 metal plus R5.7
		WSEC z2	R7.6/U0.123 to R13.3/U0.078	0.997	Use WZ cost but add R5.7 rigid, or substitute metal clips with r13.3. Base case is R8 metal clip.
Wall	Metal Bldg	IECC	R13+5.6/U0.069 to R13+13/U0.052	1.053	WZ: $0.90.
		ORCH 4M	R13+5.6/U0.069 to R15.8ci/U0.06	1.053	WZ: $1.20 for going to R15.8ci. But by u-value cost should be no more than adding R7.4 rigid so use $0.90
		ORCH 5	R13+5.6/U0.069 to R19ci/U0.05	1.053	Use WZ value of $0.90
		WSEC	R13+7.5/U0.064 to R13+13/U0.052	1.053	WZ: $0.90
Wall	Metal Frame	IECC z4m/5	No change	—	No change
		IECC z6	No change	—	No change
		ORCH	R13+7.5/U0.064 to R13+12.5/U0.049	0.644	WZ: $0.55 material cost of added R5
		WSEC	No change	—	No change
Wall	Wood Frame	IECC z4m/5	No change	—	No change
		IECC z6	No change	—	No change
		ORCH	R13+3.8/U0.064 to R13+10/U0.04	0.761	WZ: $0.65 material cost of added R6.2
		WSEC z1	R21/U0.057 to R20/U0.064	—	framing change, no change in cost. Assume more material but less time so a wash.
		WSEC z2	R21+R2.5/U0.051 to R20/U0.064	-0.322	Involves framing change and removal of rigid, no change in cost except for rigid material and installation. $0 for framing change and use 50% of WZ cost $0.55 for adding R5.

1- Costs denoted with WZ were adapted from costs developed by Woolzee Company.

Table 20. Fenestration Costs ($/ft²).

Code	Zone	Window type	U-value Increment	Cost $/ft²	Basis[1]
IECC	All	Entrance Door	U0.77	—	No change
	4 Marine & 5	Metal Curtain / Storefront, fixed	U0.45 to U0.38	2.01	Add TIM
	6	Metal Curtain / Storefront, fixed	U0.45 to U0.36	1.41	Add argon fill and 1 pass low-e
	4 Marine & 5	Metal Curtain / Storefront, Op.	U0.45 to U0.45	—	No change
	6	Metal Curtain / Storefront, Op.	U0.45 to U0.43	—	No change
	4 Marine & 5	Metal/Other, fixed	U0.55 to U0.38	1.41	Add argon fill and 1 pass low-e
	6	Metal/Other, fixed	U0.55 to U0.36	2.75	Add argon fill and 2 low-e passes - for 50%, TIM+argon+1 low-e pass for 50%
	4 Marine & 5	Metal/Other, operable	U0.55 to U0.45	0.67	Ecotope: diff between U0.55to U0.32 and U0.45 to U0.32 increment
	6	Metal/Other, operable	U0.55 to U0.43	2.35	Add 2 low-e passes for 50%, add TIM+ 1 low-e pass for 50%
	4 Marine & 5	Vinyl, fixed	U0.35 to U0.38	-0.4	Remove argon fill.
	6	Vinyl, fixed	U0.35 to U0.36	—	No change
	4 Marine & 5	Vinyl, operable	U0.35 to U0.45	-1.41	Remove argon fill, one less low-e pass
	6	Vinyl, operable	U0.35 to U0.43	-1.01	One less low-e pass
ORCH	All	Curtain / Storefront	U0.45 to U0.40	0.4	Add argon fill.
		Entrance Door	No change	—	
		Non-Metal	U0.35 to U0.30	0.4	Add argon fill.
		Other	No changes	—	
WSEC	All	Entrance Door	U0.6 to U0.77	-1.41	Remove argon fill, one less low-e pass
		Metal, fixed	U0.40 to U0.38	0.4	Add argon fill.
		Metal, operable	U0.40 to U0.45	0.4	Remove argon fill.
		Vinyl, fixed	U0.32 to U0.38	1.41	Remove argon fill, one less low-e pass
		Vinyl, operable	U0.32 to U0.45	1.41	Remove argon fill, one less low-e pass

1- Costs are determined by selecting window change to match U-value increment and then using Ecotope window technology cost data. Data generated by Ecotope Inc for 2009 WSEC deliberations.

Maximum Glazing

In ID, MT, and WA the 2012 IECC maximum glass is 30% unless 50% of the floor area is in a DLZ, in which case the maximum is 40%. The NEEA New Construction Survey data has poor information on this but the optimally shaped space with 14' floor-to-ceiling would have a wall to floor ratio of 0.47. So it is assumed that spaces with a wall to floor ratio >0.47 (approximately 10% of spaces) will be able to get 50% DLZ and therefore incur no window cost. The day light controls are added per the discussion of automatic lighting controls. Also, it is assumed that spaces that are additions will be unchanged since it is not clear the building exceeds glazing limits.

For the remaining buildings with WWR >30%, the amount of glass is a design decision and it is assumed it will not change and that all windows will need to be upgraded. In reality very high glazing cases, glass will need to be removed which might reduce the cost of the façade, in which case the costs here are over estimated.

Two cost paths are developed depending upon window frame material. Buildings with aluminum frames are assumed to need a second low-e coat costing $1/ft2 to get to U0.35, and a whole different wall systems costing $10/ft2 to get to U0.25. This later number is based on discussions Ecotope has had with glazing distributors. Vinyl framed windows are assumed to need a second low-e coat costing $0.75/ft2 to get from U0.38 to U0.32, and then cost another $2/ft2 to move to triple glazing to get U0.25. The actual cost is estimated by linear interpolation based upon the u-value needed to obtain the equivalent heat loss rate at code WWR (30%) versus the actual building WWR. Since this is delta cost, it is assumed that buildings magically get from glazing fractions above 40% to 40%, which is the limit in the old codes. Reduction here is from the as-found % glazing or 40% whichever is less to 30%. In Washington an adjustment is made to account for the base 40% including the skylight fraction.

The required U-value to obtain the equivalent heat loss rate at code WWR versus the building WWR is calculated assuming the fixed glazing code requirement of U0.38. In the maximum case of a building with 40% WWR the require u-value will be U0.285 (U0.38 *30%/40%). The cost is interpolated based upon the target u-value and the cost data above.

Elective Efficient Envelope (Oregon Reach)

The Oregon Reach efficient envelope elective requires a building have prescriptive values 10% over the standard envelope parameters. The evaluation assumes all opaque components had improved insulation by 10% and that window thermal performance improved by 10% as well, even though this would be a lower value. This value was modeled directly.

Cost for this measure is difficult to assess since it likely will be chosen only in cases where it is affordable. With little basis, the envelop cost associated with the mandatory envelope changes is scaled based upon the cost per change in heat loss rate and used to represent this measure.

Air Barrier

The 2012 IECC and Oregon Reach codes introduce explicit requirements for a building air barrier. The 2012 IECC requires buildings to use an air barrier or an assemblage of low leakage materials and specific assemblies/constructions or to test the envelope and show leakage at 75 PA of less than 0.4 CFM/ft^2 of above-grade envelope. The materials and assemblies are similar to those required by ASHRAE 90.1 - 2010. The Oregon Reach specifies sealing and that the building be “sealed with an air barrier film or approved solid”. In addition buildings over 20,000SF must be tested and have a maximum of leakage at 75 PA of less than 0.25 CFM/ft^2 of above-grade envelope.

The previous codes in Idaho, Montana, and Oregon required sealing of joints. The 2009 WSEC requires extensive sealing in all buildings. In buildings over five stories, a continuous air barrier is required and the building must be tested and shown to have leakage at 75 PA of less than 0.4 CFM/ft^2 of above-grade envelope.

Quantification of this measure is complicated by two major uncertainties. First, baseline leakage rates are poorly understood with the primary leakage set being from the whole country and dominated by east coast, particularly buildings in Florida. There are also very

few new buildings represented in the data set though the data that is present shows no diminishment of leakage in new buildings. Second, the performance of the material and sealing paths are highly uncertain. This would apply to most floor area in the IECC and to buildings less than or equal to 20,000 SF in the Oregon Reach. The Oregon Reach requirement for an explicit additional air barrier would seem to be the stronger specification.

A data set of 47 new building air leakage tests were used in the ASHRAE 90.1 - 2010 evaluation (provided by envelope committee member). The data set characterizes leakage data on the basis of CFM per square foot of building surface area. This data has a mean leakage of 1.8 cfm/ft^2 at 75 PA. Three extreme outliers in the data are responsible for moving the average from 1.0 cfm/ft^2 to 1.8 cfm/ft^2. The median is also 1.0 cfm/ft^2. The 2005 NIST paper ("Airtightness of Commercial Buildings in the US" by Emmerich and Persily) has a mean of 1.54 cfm/ft^2 (SF does not include floor), with higher levels in warehouse and lower in office for all climates. The paper also shows a strong correlation between air tightness and heating degree days, with much lower leakage rates in colder climates. The data has an average of 0.99 cfm/ft^2 for climates with >2000 degree days, with the caveat that they have little data for the western US.

PNNL evaluated this measure for inclusion in 90.1 - 2010. The 90.1 language is very similar to the prescriptive sealing requirements in the 2012 IECC (except for the concrete masonry wall requirements, which are notably less than IECC). It does not specify an additional film, but it does require the air barrier to be specifically detailed on the plans. PNNL choose to use the mean value of the aforementioned data set (1.8 CFM/ft^2) as the baseline. They assumed that the sealing language would reduce the infiltration 45% to 1.0 CFM/ft^2, and that a testing requirement would be needed to get lower.

The current analysis assumes a baseline leakage of 1.0 CFM/ft^2 of exterior surface. Sealing and material language will be assumed to achieve a 45% reduction, and testing will be assumed to achieve the remaining increment to the maximum allowed test result. This is "conservative" in that the lower baseline assumption means the sealing language will be assumed to reduce infiltration by 0.45 CFM/ft^2 compared with the 0.8CFM/ft^2 increment used in the 90.1 evaluation. In terms of a real baseline, this value may yet prove to be high. In Washington, large offices are assumed to be tested to 0.4CFM/ft^2 in the base code. In Oregon, most buildings are assumed to be tested to 0.25CFM/ft^2 for the Reach Code with the exception to small office, small retail, and restaurants.

The cost of compliance with air barrier requirements is not well characterized in this work. The cost of testing has been estimated based on very little information at \$0.34/ft^2 of floor area. The cost of compliance through specific materials or air barrier systems is assumed to cost the same amount.

HVAC Equipment Efficiency

Cooling Efficiency

The minimum cooling efficiency requirements for larger (>5 ton) unitary water and evaporatively cooled equipment and PTAC/PTHP equipment are increased in all codes. These increases were incorporated into the CFR during 2008 with effective dates of June 1, 2011 and October 8, 2012, respectively. The current and future code minimum efficiency is calculated from the NEEA New Construction Survey data, and the proportional shift in

cooling efficiency modeled. No cost is assumed since these efficiency levels are or will shortly be federal law.

Boiler Efficiency
The minimum heating efficiency requirements for boilers increase between the 2009 and 2012 IECC. The minimum heating efficiency requirements for boilers increased in ASHRAE 90.1 as of March 2, 2010. The 2009 WSEC and 2012 OEESC incorporated these increased requirements, but the 2009 IECC did not. The resulting boiler efficiency change was modeled in four prototypes with boilers. The average boiler savings from these were used for the fraction of floor area occurring in other building types with boilers. No cost is assumed since these efficiency levels are the manufacturers' consensus developed for the national code.

PTHP Heating Efficiency
The federal minimum heating efficiency requirements for PTHP equipment increased as of October 8, 2012. A 2012 IECC oversight results in an unchanged minimum efficiency value rather than the new value being referenced. Oregon also does not adopt this provision in its base efficiency package. Thus for the evaluated codes there is no measure here. If code is amended to comply with the federal minimum efficiency standards, then PTHP efficiency would increase by approximately 6% on average. No cost is assumed since this is based upon federal minimum efficiency standards..

HVAC Equipment Efficiency – High-Efficiency Option

The 2012 IECC and Oregon Reach have high-efficiency HVAC options, though they vary in the details. The IECC states that the high-efficiency path is only available if C406.2 (high-efficiency path table) performance is not better than the C403.2 (base prescriptive path) requirements. This becomes an issue, as many equipment types have very similar or arguably the same efficiency between the two tables (water-cooled chillers). Correspondence with ICC staff indicates that if the equipment is listed, then for most cases it qualifies. If it is listed in the base tables but not the high-efficiency tables, then it does not qualify (ground source heat pumps). Non-regulated equipment (electric resistance, gas fired infrared, VRF) is not required to be improved. If a building is electric resistance with one PTAC unit, as long as the PTAC unit meets C406.2 requirements, then the building qualifies as meeting the extra mechanical efficiency path.

The Oregon Reach makes two changes to this formula. Water cooled chiller efficiencies have been increased so that it is clear chillers both qualify for the path and achieve some energy savings. And any equipment listed in the base tables but not listed in the high-efficiency table can qualify if it achieves 10% better performance.

Both codes list high-efficiency options to all classes of regulated combustion equipment and require similar levels of combustion equipment efficiency, which in effect require condensing combustion. The improvement in cooling efficiency is highly variable.
The codes have similar requirements, except for water-cooled chillers, where the Oregon Reach requires better efficiency.

There is some question as to how many building types can utilize this path. In particular, buildings with rooftop package equipment will have a hard time attaining the required combustion efficiency values. They likely would need to either switch to electric heat, where

the efficiency is unregulated, or to heat pumps, where the efficiency increment is at least attainable. In practice, only projects without rooftop package equipment are likely to follow this path. This is why the Oregon Reach chiller efficiency changes are significant.

The fraction of floor area cooled and the fraction heated by each heat source is determined from the NEEA New Construction Survey data.

Cooling Efficiency
The future code base and high-efficiency option minimum efficiencies are calculated by applying the code requirements to the equipment inventory from the NEEA New Construction Survey data. Energy savings of this change are estimated by modeling the average proportional shift in cooling efficiency. All equipment as assumed to qualify for the path, including chillers in the 2012 IECC.

Combustion Efficiency
The future code base and high-efficiency option minimum efficiencies are calculated by applying the code requirements to the equipment inventory from the NEEA New Construction Survey data. Energy savings from this change are estimated by modeling the average proportional shift in heating efficiency by equipment class. The boiler efficiency change was modeled in four prototypes with boilers. The average boiler savings from these were used for the fraction of floor area occurring in other building types with boilers. The furnace/unit heater change was modeled in eight prototypes with furnaces and unit heaters. The average furnace/unit heater savings from these runs was used as the savings rate for floor area occurring in other non-modeled building types with furnaces and unit heaters.

Heat Pump Heating Efficiency
Heat pump heating efficiency is estimated using an engineering calculation based upon the modeled heating energy. The modeled heating energy (mostly gas furnaces) is converted to heat pump energy assuming an average combustion efficiency of 0.75 and an average heat pump COP of 2.1. The future code base and high-efficiency option minimum efficiencies are calculated by applying the code requirements to the equipment inventory from the NEEA New Construction Survey data. The average base efficiency and efficiency increase are calculated separately for air source and water source heat pumps, and the change in efficiency is applied to the estimated heat pump heating energy.

Cost Estimate
Cost data for high-efficiency equipment is difficult to develop. DX and chiller cooling and heat pump costs were developed from the California DEER data base in the same manner as costs used in the NPCC Sixth Plan. These costs generally took the form of an equation with a fixed component and a capacity dependent component. The cost per square foot was developed by building type by applying the cost formulas to the equipment inventory found in the NEEA New Construction Survey.

Gas heating equipment costs are woefully out of data and are based upon work done for Washington Natural Gas (Kennedy, et al. 1995). Costs are not inflated. This decision is made because the gas equipment cost is of less interest to BPA and also because the data is so out of date that it is likely equipment cost has changed for reasons other than inflation, perhaps even decreasing.

HVAC System Fan Power (WA)

Regulating system fan power is a significant change moving from the 2009 WSEC to the 2012 IECC. The impact of this change is hard to assess given the limited information available. Given the importance of fan power, considerable effort was spent analyzing the NEEA New Construction Survey data. However, due to the uncertainty of the data, no savings have been estimated. A discussion of the data follows.

The NEEA New Construction Survey data has supply flow and motor horse power of the air handler for 47% of the systems. However, terminal fan power data for VAV systems with series or parallel fan powered terminals is very incomplete and impossible to aggregate with the central fan power within the current data structures. This means the estimated fan power for these systems is under-predicted. The data also has limits in generating the code allowances. Several important traits are not available, resulting in allowances that are under-predicted. System traits such as heat recover, filtration, and sound attenuation sections are either not recorded or not recorded by the system. This means assignment of the code allowances for these devices is not possible and results in a large impact on allowance in healthcare, and for some school systems.

Despite these constraints the NEEA New Construction Survey reported and code allowance fan power were calculated and reviewed. Fifty-five percent of the systems with data fall below the 5-HP threshold where fan power begins to be regulated in the 2012 IECC. This indicates code provision will apply to systems serving approximately 45% of the floor area.

Healthcare systems were excluded from further analysis due to the severe data limitations in calculating code allowance. For the remaining code applicable systems, which serve only 17% of the NEEA New Construction Survey floor area, the as-found fan power and code allowance were examined. This is an uncertain enterprise with statistical uncertainty due to small sample sizes and issues of how data should be weighted as the number of data points becomes a small subset of the overall sample. The standard deviations for the as-found conditions are 40% to 50% of the mean.

Table 21 presents the mean fan power and code allowance for the remaining non-healthcare systems separated by constant volume and variable volume systems. For both the constant and variable volume systems the calculated code allowances are biased low since extra fan power allowed for sound attenuation, filtration, or heat recover equipment could not be assigned because the audits either did not track this or didn't track it by system. Looking at only the Total rows, the as-found fan power is lower than the code allowance for both constant and variable volume cases. The larger difference for the VAV systems is explained by the exclusion of terminal fan power from the as-found fan power.

The code impact was examined two ways. First, the average difference in the mean as-found and code-allowed values is presented in the "As-Found-to-Code" column. This shows the average as-found value is below the allowed value for the regional total. Second, the mean difference between the as-found and the code compliance fan power is presented in the Compliance Δ column. This reduction was calculated assuming any systems above code would achieve code and that units better than code would not change. The difference between the as-found and the compliance value is reported. It assumes 100% compliance with the allowance as calculated. The average reduction in fan power for constant volume systems is 0.00021 hp/cfm. Full compliance with the allowance as calculated here would result in a 20% reduction in the average fan power. The average reduction in fan power for

variable volume systems not in Oregon is 0.00018 hp/cfm, which is 13% of the as-found fan power.

These are large savings, but several factors must be considered. First, this assumes full compliance with the code. It is reasonable to assume some of the non-complying buildings will be made to comply. It is not reasonable to assume all of them will, particularly in an area of the code that is rather complicated. More importantly, buildings not complying with the motor nameplate requirement can comply based upon the brake horse power allowance. Many of the worst offenders likely have oversized motors and fans and likely will improve significantly when looked at based upon brake horse power. Full compliance with one of the duel compliance paths will change systems much less than assumed here.

Examining the data by state finds a chaotic relationship most likely driven by the small sample sizes. When the NEEA New Construction Survey buildings were constructed, Oregon regulated fan power for non-package and package variable volume equipment. The Oregon allowances were similar to the 2012 IECC. It was thought major impacts might be apparent from differences in the as-found fan power. In this summary there is no difference in the mean values for the variable volume systems. The median values show Oregon with more efficient systems, but the difference is well within the statistical uncertainty. Also, using the available metrics the Oregon systems show similar potential energy savings from applying this code provision even though the Oregon systems were built to comply with this provision, which calls into question the base data source here.

Table 21. Fan Power and Code Allowances (Excluding Healthcare)

State	Systems (N)	As-Found (hp/CFM)	Code Allowance (hp/CFM)	As-Found-to-Code Δ (hp/CFM)	Compliance Δ (hp/CFM)
Constant Volume Systems (mean)					
ID, MT, WA	173	0.00097	0.00114	-0.00017	0.00018
OR	64	0.00130	0.00118	0.00012	0.00029
Total	237	0.00105	0.00115	-0.00010	0.00021
Variable Volume Systems (mean)					
ID, MT, WA	94	0.00138	0.00156	-0.00018	0.00018
OR	72	0.00134	0.00158	-0.00024	0.00012
Total	166	0.00136	0.00157	-0.00021	0.00016

No savings have been calculated for this measure. This decision was made as a result of the large uncertainty, the known biases in the allowance values, and the availability of an alternate compliance path that will mean many projects not complying here will in fact comply based upon brake horsepower. Further research of available baseline information is recommended.

Currently fan power is completely unlimited in Washington, but buildings wishing to be LEED certified must be compared with fan power provisions in ASHRAE 90.1. Reports from modelers in the field indicate fan power limits are an issue in many buildings.

Lighting Power Allowance

The change in maximum lighting power allowance is examined for all code changes. For codes with both a building area and space-by-space method, only the building area method was examined. For Idaho, Montana, and Oregon the minimum allowances for the new codes are the same or lower in all cases. In Washington, the maximum allowances increase slightly in most cases. All future codes have an optional high-efficiency lighting path, which is also evaluated. In all states, the combination of these two steps represents a large improvement over current codes.

Energy savings from LPD code changes were estimated by simulating prototypes using characteristics data derived from the NEEA New Construction Survey data. For each building, lighting area data was used with the base and adopted codes to calculate the whole building LPD for the as-found building, and the maximum LPD allowance for the base and the potential future code. The energy code whole building maximum allowances were applied at a tenant/major space level within each building, which is typical of enforcement though not universal. The proportionally shifted LPD for each code was calculated from the as-found, and base and future code values for Idaho, Oregon, and Washington. The difference in the base and future code proportionally shifted LPD was taken to be the code impact.

Montana was treated differently because the 2001 Montana code had very liberal LPD requirements, and the implied current LPD of a proportional shift was unrealistic. The difference in the base and future code compliance LPD+5% values was taken to be the code impact for Montana. See Appendix E and Table E2 for more details.

These delta values were averaged by building type. The prototypes have space-appropriate LPD in each space that were scaled to reproduce the appropriate average LPD for each code and scenario.

Table 22 provides summary LPD results for the chosen scenario applied to data found in the NEEA New Construction Survey study. The Code LPD values are the average LPD of applying the code to the regional buildings. The base LPD is the average LPD of the compliance +5% scenario for the given code. This was used as the base LPD in the prototype models. The "Delta LPD" column is the average savings increment based upon the savings scenario discussed above.

Table 22. Average LPD Inputs by State Code (W/ft²). NEEA New Construction Survey[1]

State	Average Code Required LPD (W/ft²)			Average Modeled Base LPD (W/ft²)	Average Future Code LPD Reduction (W/ft²)	Average Future High-Eff. Option LPD Reduction (W/ft²)
	Base Code	Future Code	Future Code High-Eff. Option			
ID/MT	1.15	1.07	0.92	1.04	0.063	0.132
OR	1.06	1.00	0.90	0.98	0.055	0.100
WA	1.02	1.07	0.92	0.95	-0.02[2]	0.132

1 – Average LPD for all building in baseline study
2 – True proportional shift would be smaller (more negative) than this. Value modeled was limited by the calculation framework. If this WA lighting increment becomes important the framework should be rebuilt to handle this case better.

The NEEA New Construction Survey is not large enough for the proper characterization of building type LPD within each state. Therefore each states code was applied to all buildings in all states and the evaluation increment determined. This assumes that the building configurations are not strongly correlated by region and that the increased number of buildings within a building type will lead to better results.

Even with this approach, the NEEA New Construction Survey was designed as an aggregate sample and is not large enough to properly characterize most building types. This work assumes that building type LPD values can be used in models to predict building type energy savings that when aggregated across building types will be valid just as the underlying LPD characteristic. The actual values modeled were determined by state and building type to capture the building type variation in LPD change, but individual building type results cannot be used with confidence. The results of this analysis are valid only as sector aggregate savings.

Building Versus Space-by-Space Lighting Power Allowance

The Oregon Reach and the 2012 IECC implement a dual path minimum lighting power density allowing buildings to comply with either the building path or the space-by-space path. Buildings are free to choose the method that yields the largest allowance for their particular building, and having two paths has the net effect of raising the lighting power allowance for some portion of projects.

Unless these two paths are carefully synchronized, uncertainty can be created as to the impact of code changes. For example, the restaurant building lighting power allowance decreases by approximately 30% with the Oregon Reach code, but the space-by-space values for the main restaurant areas of dining and food preparation are unchanged. This leads in the reach code case to the building LPD being much lower than either the dining or kitchen LPD. This allows projects to largely avoid the new requirements.

Warehouse is another area where there is a serious disconnect between building and space-by-space allowances, with building allowances being substantially below the typical major space allowances. Both allowances improve, so with the proportional scenario the savings are similar, but with code-to-code or compliance scenarios there would be substantial differences.

A second issue arises in Idaho, Montana, and Washington, which are moving from a building-path-only allowance to a dual path approach in the base package for the 2012 IECC. If the only change were the additional space-by-space path, some projects that did not previously pass would pass the new code. Therefore if the new code on a building basis is the same as the existing code, the net effect is a reduction in code requirements. Unfortunately the 2005 Baseline building data does not provide a good basis for assessing the space-by-space path. Fortunately from an evaluation perspective, the IECC lighting efficiency optional path provides only the building path.

Cost Estimate

The cost of lighting power reduction was estimated using the NPCC Sixth Plan cost assumptions with saturations of various lighting types determined from the NEEA New Construction Survey data.

For each evaluated building type, the main lighting types were determined from the NEEA New Construction Survey data and the LPD attributable to incandescent, HID, and standard T8 lighting calculated. For each building type and lighting technology the NPCC Sixth Plan has developed measures (termed "Proxy" measures) that result in a percentage reduction in lighting watts and a cost per saved watt. The NPCC Sixth Plan percentage savings and cost per saved watt were applied to the estimated LPD of each lighting type to get the total Sixth Plan energy savings and cost for each building type.

In general, the NPCC Sixth Plan efficiency improvements are larger than the code compliance improvements. To adjust the NPCC cost to represent the evaluated code efficiency improvement, the fraction of candidate fixtures that were improved was reduced for each building and lighting type so that the achieved LPD was similar to that of the modeled code increment. The resulting cost data is therefore for the same efficiency improvement as the energy calculations.

Table 23. Average Cost of LPD Reduction by State Code (W/ft²). NEEA New Construction [1]

	Average Code LPD Reduction		Average High-Eff. Option LPD Reduction	
State	(W/ft²)	($/ft²)	(W/ft²)	($/ft²)
ID/MT	0.063	0.021	0.132	0.055
OR	0.055	0.033	0.100	0.041
WA	-0.02[2]	-0.004	0.132	0.045[3]

1 – Average LPD for all building in baseline study
2 – Proportional shift would be larger than this. Value modeled was limited by the calculation framework. If this WA lighting increment becomes an important the framework should be rebuilt to handle this case better.
3 – Cost varies from ID/MT cost due to differences in projected mix of building types and lighting types.

Automatic Lighting Controls

Future energy code lighting control requirement changes vary significantly between the codes. The 2012 IECC adds several control requirements beyond the 2009 IECC, the Oregon Reach code adds OS requirements for storage areas, and the shift from the 2009 WSEC to 2012 IECC adds and subtracts requirements in a complex, overlapping manner. Lighting control measures are difficult to assess, as most involve levels of occupant interaction as well has interacting with each other. Simulation models do not model these controls.

Rather, they model the impacts of assumed changes in the fraction of lighting on. This fraction of lighting on-time is generally determined from field studies. Therefore this analysis has taken a simplistic approach to calculating savings for most lighting control measures. A fractional savings factor is applied to the model-predicted lighting energy use and adjusted for model-predicted lighting interactions.

All new lighting controls are evaluated on a single worksheet with the exception of the IECC minimum skylight measure, which is evaluated separately. Due to the complex overlap between the various measures, all IECC daylight provisions are estimated assuming no daylight control in the baseline. The savings from current WSEC daylight requirements are subtracted out with the TopDaylight (WA) and SideDaylight (WA) worksheets.

The analysis of automatic daylight control in the IECC 2012 is extremely complicated and will use a mix of approaches. The daylighting requirements are largely implemented as a trade-off for higher allowed levels of fenestration, or in the Additional Efficiency efficient lighting measure as a trade-off for higher allowed LPD. The paths are not always closely correlated in terms of energy savings potential, and the chosen path is never certain. Some are more in line with current practice, and the analysis generally assumes that as the analysis path.

Costs for the first cost of these control changes have been developed. Controls that shut off lighting will also reduce O&M expenses as lamp life is extended. This is a small effect.

Lighting Controls – Automatic Shutoff in Small Buildings (2009 IECC to 2012 IECC)
The 2012 IECC extends the requirements for automatic shutoff controls to all buildings. Previously this requirement only applied to buildings over 5000 ft^2. Buildings under 5000 ft^2 are assumed to have bi-level control without automatic shutoff, and it is assumed they will adopt OS control without bi-level control for all areas as part of the new automatic shutoff control requirements.

The percentage of the floor area in buildings less than 5000 ft^2 was determined by building type from the CBSA data set since the number of buildings in this size range in the Baseline data set was so small.

Savings, where applicable, were assumed to be 10% of the simulation predicted lighting energy use. This is in line with CEC findings, but is lower than used elsewhere. In this work automated shutoff in small buildings is discounted on the assumption that night shut off is reliably done in most small buildings.

Small retail, grocery, and restaurants are assumed to be controlled precisely based upon the retail hours and security considerations allowing no savings from automatic shut of control except in storage areas and other ancillary areas.

Based upon the NEEA New Construction Survey data, the current saturation of automatic shutoff is low in small offices. School classrooms, however, have a significant current saturation. How applicable this is to very small buildings is debatable.

Occupancy sensors control cost is derived from the NPCC Sixth Plan room occupancy sensor cost, which is estimated at $0.25/ft^2. The base system is a multi-level control that does not need to be installed in spaces with OS control. The NPCC Sixth Plan cost for bi-level control is $0.15/ft^2. The net cost of automatic shutoff is $0.10/ft^2. This is then inflated to 2012 dollars.

Occupancy Sensors - Private Office/Conference/Classroom (2009 IECC to 2012 IECC)
The 2012 IECC requires occupancy sensors in classrooms, private offices, meeting and conference rooms and store rooms. This measure overlaps the requirement for automatic shutoff, particularly in smaller buildings where the primary method of compliance is likely to be OS controls. Spaces with occupancy sensors are exempted from requirements for bi-level lighting control.

This analysis assumes buildings over 5000 ft^2 have bi-level with automatic sweep control and will move to OS control only. Buildings under 5000 ft^2 are discussed separately under the section titled "Automatic Shutoff in Small Buildings."

Savings from this measure rely on data developed by the City of Seattle and the California Energy Commission (CEC). The data is assumed to be applicable to Idaho and Montana. Occupancy sensor control over bi-level switching and automatic time clock shutoff is assumed to reduce lighting energy by 15% over lighting with time clock and local bi-level switch control in offices and conference rooms. A recent study that monitored office occupancy found savings of 28% in enclosed offices and 32% in classrooms (Mahone et al). This savings estimate includes savings from shutoff during occupied and unoccupied hours at night. Since the base case condition for larger buildings already has automatic shutoff, and the base case has bi-level control, which is estimated to save 5% (discussed later), the 15% savings number is reasonable.

A small survey of Seattle office lighting found daytime office occupancy rates of 58% (Kennedy, Baylon 2001). Auditors noted a significant amount of lighting turned on with spaces unoccupied. Other studies have found similar occupancy rates (Mahone et al). Classrooms are assumed to comprise 39% of education floor area (NEEA New Construction Survey) and occupancy sensors are assumed to save 10% in these spaces (from CEC). This savings estimate is significantly lower than the Mahone work and so has not been adjusted for the bi-level control base condition.

Based upon the NEEA New Construction Survey data, the current saturation of occupancy sensors is low in offices. School classrooms however have a significant current saturation. We assumed 20% saturation.

Occupancy Sensors - Warehouse (WA and OR)
The Oregon Reach adds a requirement for OS control in warehouses while the current WSEC requirement for OS control will not be required under the 2012 IECC. WSEC section 1513.6, which requires warehouse areas to have occupancy sensors, has two exceptions that may be applied to warehouse spaces. It exempts spaces "illuminated in a manner requiring manual control" and industrial and manufacturing spaces "as may be required for production." In all other cases the IECC, which does not require OS control, will be a step backwards.

The NPCC Sixth Plan estimated savings of 35% for controlled fixture, with 80% of the fixtures controlled. These numbers are assumed here. An additional adjustment for current saturation is also made here.

Occupancy sensors control cost is derived from the NPCC Sixth Plan open office occupancy sensor cost, which is estimated at $0.30/ft$^{2.}$ This is then inflated to 2012 dollars.

*Lighting Controls – Bi-level (*2009 WSEC to 2012 IECC*)*

The 2012 IECC has requirements for bi-level lighting controls that allow occupants of most buildings to choose from three levels of illumination. Savings predictions for this control are highly variable. A recent monitoring study of bi-level lighting estimated savings to be 8% in schools and 17.9% in offices (Mahone et al). Several important factors are not addressed in the study. First, the spaces were not new and do not represent current lighting systems or levels. Only spaces with lighting power over 1 watt per square foot were included. It's entirely possible that some of the spaces had more light in one of the partial switch states than current codes allow.

The study also assumed that the baseline condition was all lighting on. While this might seem reasonable, the study found a significant number of occupied hours when all lighting was switched off. If one assumes that the baseline condition is a weighted average of the off and on condition, the savings estimate in offices drops to 2.4% and it is negative in classrooms. The authors of the study did not agree with this interpretation of the data, and increased usage in classrooms seems like a suspect conclusion.

ASHRAE 90.1 2010 allows a credit for continuous manual dimming of 5% in office, 10% in conference and retail spaces, and zero in all others.

Five percent was chosen in this work as a compromise. The current saturation is assumed to be zero. The applicable floor area is limited. Exempt areas include corridors, equipment rooms, store rooms, restrooms, public lobbies, electrical/mechanical rooms, sleeping units, spaces with occupancy sensor control, daylight zones with automatic harvest controls, and most warehouses. Warehouses are exempt if the LPD is <0.6 W/ft^2 which is the maximum lighting power allowed with the building method for warehouses. Using the space-by-space method, fine materials warehouse spaces are allowed up to 1.4 W/ft^2.

Bi-level control cost is derived from the NPCC Sixth Plan at $0.15/ft$^{2.}$ This is then inflated to 2012 dollars.

Automatic Daylight Controls (2009 IECC to 2012 IECC)

The analysis of automatic daylight control in the IECC 2012 is extremely complicated in that daylighting requirements are largely implemented as a trade-off for higher allowed levels of fenestration, or in the Additional Efficiency efficient lighting measure as a trade-off for higher allowed LPD. The paths are not always closely correlated in terms of energy savings potential, and the chosen path is never certain. Some are more in line with current practice, and the analysis generally assumes that as the analysis path.

Increased Window with Side Daylight Controls (2009 IECC to 2012 IECC)

The 2012 IECC allows a maximum vertical fenestration area 30% of gross wall area. This maximum is increased to 40% if at least 50% of the conditioned floor area is within daylight zones that have "automatic daylight control." This analysis assumes that spaces found in the

NEEA New Construction Survey with more than 30% window will adopt designs with automatic daylight control as the path to allowing the higher glazing fraction. There is poor information in the baseline to determine the achievable daylight zone fraction. Spaces not able to achieve this would need to improve some other aspect of the building or change the building geometry. This analysis assumes buildings will be able to achieve the 50% of floor area being within daylight zones, and if not, any alternative will have comparable cost and savings to side daylight controls.

The IECC defines automatic daylight controls as either continuous dimming that reduces general lighting power continuously down to 35%, or stepped dimming with a minimum of two control channels per zone, with one step being between 50% and 70% power and the other being less than 35% power. The intent here seems to be that the less than 35% not be zero, but the language does not preclude this strategy.

Savings fractions of 50% for the controlled area are taken from the NPPC Sixth Plan. The savings are reduced to 45% since most spaces would have been required to implement bi-level control in the 2009 IECC. This savings fraction was applied to the simulation derived lighting energy.

Costs for this provision are derived from the NPCC Sixth Plan. The NPCC Sixth costs (PC-SideDaylight-6P-D1.xls) assume continuous dimming and vary by building type with a range from $0.78 to $1.28 per treated square foot. The baseline control for this measure is bi-level control whose cost is estimated at $0.15/ft^2 (PC-Lighting Controls Interior-6p-D5.xls). Costs are inflated to 2012 dollars.

Increased Skylight with Daylight Controls (2009 IECC to 2012 IECC)
The 2009 IECC allows a maximum skylight area of 3% of gross roof area. The 2012 IECC is the same but is increased to 5% if spaces have "automatic daylight control." Spaces with more than 3% skylight previously had to improve some other aspect of the envelope. Under the 2012 IECC, buildings do not have to improve the envelope if the automatic daylight controls are installed. The NEEA New Construction Survey found that all spaces with significant skylight fractions implemented automatic daylight control, so the new controls requirement will not change current practice or save energy.

This measure is evaluated as part of the envelope calculations as a weakening of the envelope requirements, with the assumption that no additional lighting controls will be required. No credit is taken for the required controls. In this case, building costs would be reduced as the cost associated with improving other areas of the envelope to compensate for high skylight levels is no longer incurred. However, no cost reduction was assumed for this measure.

Minimum Skylight and Daylight Controls (IECC – Zones 4 and 5 Only)

The 2012 IECC requires skylights in most enclosed Zone 5 spaces larger than 10,000 ft^2 that are directly under roofs with ceiling heights 15 feet or higher and have an LPD >0.5W/ft^2. This generally will apply to the main gymnasiums in high schools, main sales floor in box retail, and some warehouse spaces (only required if LPD is >0.5W/ft^2). The amount of skylight required is 3%, or that amount required to satisfy a formula accounting for the skylight VT and light well depth.

The daylight control zone must cover 50% of the area and have "multi-level" daylight control. This control must reduce the lighting power in response to daylight available in the space and can draw no more than 35% power when the day lit illuminance is greater than the rated illuminance of the general lighting. This control was not observed in the NEEA New Construction Survey. All buildings implemented multi-step dimming.

Savings for this measure are modeled in retail, warehouse, and schools using a 3% skylight-to-roof ratio and step dimming.

Applicability of this provision is assumed to be limited to the fraction of high school gyms, box retail, and highly lit warehouse floor area that had LPD <0.5 W/ft^2 and was found to not have skylights with automatic harvest in the NEEA New Construction Survey.

Skylight and automatic step dimming control costs are derived from the NPCC Sixth Plan. Where smoke vents are required, i.e., warehouses and rack retail, changing smoke vents to skylights is assumed to be a no-cost option. The NPCC Sixth Plan skylight cost for a 1% skylight fraction is $0.6328 (2008$) per square foot of floor area. Inflated to 2012 dollars results in $0.6743/ft^2.

The required skylight-to-roof ratio is assumed to be 3% in retail and school and 3% in warehouse. Smoke vents are required in areas with storage racks above 12 ft. height unless certain sprinkler systems are installed. Typically this is approximately 1% of floor area. Smoke vents are assumed to be installed in all warehouses and one-third of retail and grocery (warehouse retail, home improvement, and back storage areas).

Not credit is taken for reduced lighting O&M that results from reduced lighting run times.

Optional Increased Lighting Efficiency

The 2012 IECC and the Oregon Reach have optional increased lighting efficiency paths primary involving reduced lighting power. The 2012 IECC also adds control requirements, which in this analysis are evaluated separately. The combined savings are the optional lighting efficiency savings.

The 2012 IECC has a building method lighting table with LPD that are from zero to 20% better than the standard building method values. There is also no separate display light allowance and, more significantly, there is no space-by-space path. This later factor would be a large decrease in allowance for some building types such as warehouse. Unfortunately this analysis is limited to the building area method path, so any savings that might result from the lack of a space-by-space path are not accounted for. The Oregon Reach simply requires buildings to have lighting power 10% lower than the maximum code requirements.

The analysis for this measure is identical to the mandatory lighting LPD measure.

Increased Maximum Allowed LPD with Daylight Controls

The 2012 IECC increased lighting efficiency option allows offices and retail to not install less lighting power in certain circumstances when they have automatic daylight controls. These provisions have a complex interaction with requirements for minimum skylights with daylight controls in large rooms, and with side daylight requirements in buildings with high

glazing fractions. This analysis assumed that the lower LPD path was pursued unless similar controls are required by some other aspect of the code. All savings and costs are evaluated based upon the LPD resulting LPD rather than control requirements.

The maximum Office LPD raises from 0.85 W/ft^2 to 0.9 W/ft^2 if at least 30% of the "conditioned floor area" is within daylight zones with automatic daylight controls.
It is assumed that offices will choose the lower LPD path unless they have levels of vertical fenestration greater than 30% which would already require "multi-level" control. The only additional requirement to get the higher LPD allowance is for the IECC defined automatic daylight control to be installed rather than multi-level control. Both require automatic control to 35% power, but the multi-level does not require the intermediate step. This seems like a fairly meaningless distinction in real world controls, with most systems more than capable of providing the intermediate step. The real world multi-level control is assumed to be equivalent to "automatic daylight control" even though the definitions are slightly different.

Buildings with lower glazing fractions are assumed to have no problem meeting the lower LPD. This is a simpler analysis, and most buildings in the NEEA New Construction Survey were not found to have side daylight, but many had LPD less than 0.85 W/ft^2. In low WWR offices, savings accruing from the two approaches should be somewhat similar, so choosing only one option to evaluate is reasonable.

The maximum retail LPD is increased from 1.30W/ft^2 to 1.4W/ft^2 if at least 70% of the "floor area" is within daylight zones with automatic daylight controls. The analysis is complicated due to the high frequency of top daylighting control in retail as found in the NEEA New Construction Survey, and by the large savings of this control relative to the LPD increment. Since the base 2012 IECC requires large areas with ceiling heights >15 ft. to have skylight, it is assumed that single story buildings with >15-ft ceiling heights will choose daylight control and be allowed the higher allowance, and all others will choose the lower LPD path. The primary difference is that the large room requires 50% of the zone to be daylight, and the LPD requires 70% to be daylight.

Costs for the LPD component of this measure are estimated in the same way as the mandatory maximum lighting power provisions. In offices and retails, lighting power is not decreased when certain automatic daylight controls were installed. However, all costs are calculated based upon the LPD difference.

Warehouse Daylight Control Requirements

The 2012 IECC increased lighting efficiency option requires that warehouses have 70% of the floor area in daylight zones with automatic harvest. This is a step beyond the minimum skylight requirement in that it: is required in all warehouses no matter the size or LPD; requires 70% rather than 50% of the space to be in the daylight zone; and requires two-step or continuous dimming rather than single-step. Savings for this measure are modeled and applicability is calculated to dovetail with the minimum skylight provisions of the code.

Costs for this were developed from the NPCC Sixth Plan. The 2008 cost for 2% skylight with step control is \$0.67/ft^2. This cost includes credit for 1% smoke vents that are assumed to be converted to skylights at no cost. Inflated to 2012 dollars using the CPI-U gives a cost of \$0.71/ft^2.

Optional Renewables

The 2012 IECC and Oregon reach offer renewable optional increased-efficiency paths. The IECC option requires renewable capacity of 1.75 BTU/ft^2; or 0.5 W/ft^2; or that needed to produce >3% of building mechanical, water, and lighting energy use. The Oregon Reach, which requires users to choose one increased-efficiency option and two project electives has three separate renewable requirements. The increased-efficiency option is the same as the 2012 IECC. The project elective renewable path requires renewable capacity of 1.02 BTU/ft^2; or 0.3 W/ft^2; or that needed to produce >2% of building mechanical, water, and lighting energy use. If the renewable increased-efficiency option and project electives are both chosen, then the combined capacity needed is enough to produce >4% of building mechanical, water, and lighting energy use.

The analysis of this measure assumed photovoltaic cells are installed and that, if beneficial, projects will model consumption to utilize the percentage of building consumption threshold rather than the prescriptive watts per square foot threshold. The modeling approach to determining building use for this threshold is specified in Oregon Reach. The 2012 IECC does not specify how it is determined, and it seems plausible that one might base the expected usage on some average consumption data or modeling work rather than customized modeling. Based upon simulation and a mid-range load factor, the required PV installation to attain 3% would be around 0.2 W/ft^2 for office, retail, schools, and warehouse. Hospital, restaurant, and grocery would be higher and therefore would utilize the base 0.3 or 0.5 W/ft^2 requirement.

Costs estimates are difficult given the current turmoil in the PV market. Barbosa et al. established that installed PV costs vary widely by installation capacity, state, and year. Preliminary data indicates that 2011 costs have dropped by approximately 5%. State level data for northwest states is limited to Oregon and has very limited system size information. Looking at variation of states with large numbers of installs, Oregon costs look average to a bit lower. The national average installed cost in 2010 was $6.2 per watt, but system size impacts the cost by 50% or more. The required PV capacity was determine for each building in the NEEA New Construction Survey based upon modeled consumption. The capacity distribution was calculated for less than 2000 W, 2000 W to 5000 W, and greater than 5000 W, and costs were assigned to each based upon the Barbosa findings.

Project Elective - DHW (Oregon Reach)

The DHW project elective requires that water heating equipment be 10% more efficient than OEESC minimum efficiency standards. Savings are estimated as a 10% reduction in water heat energy. No cost was developed for this measure.

Commissioning

The 2012 IECC and Oregon Reach codes introduce explicit building commissioning requirements for the mechanical and lighting systems. The requirements of the two codes are different in terms of language and specifics, but they both specify building commissioning and the impact of the language differences in practice is hard to anticipate. The previous codes in Idaho, Montana, and Oregon required test and balance of air and hydronic systems and the provision of basic system manuals. Commissioning is a significant new requirement of the future codes in these states. The 2009 WSEC already requires commissioning.

The potential energy savings for this new code requirement are very large but also highly uncertain. The relevance of commissioning studies to date is questionable. A key issue, how code-driven commissioning in all buildings compares with incentivized third-party commissioning in complex buildings, is crucial since most of the cost and savings data are dominated by incentivized commissioning of complex buildings.

Quantifying savings for this are essentially a very significant guess, and the result has an outsized impact on overall savings because it is applicable to nearly all floor area. The basic approach here follows the same approach used in the NPCC Sixth Plan (PC-HVACControls-6P-D4.xls, Notes & Sources 2008). Estimated savings from commissioning is documented in various studies, and this value is taken to be representative of third-party and/or owner-driven commissioning in complex buildings.

A significant review of commissioning studies was conducted as part of the NPCC Sixth Plan. This included studies by NEEA, PECI and LBNL. Since then, LBNL has published a second commissioning evaluation that is based upon an expanded sample. Unfortunately the LBNL sample increase includes very few additional new construction projects, and the savings data made available is much less detailed that previous work, making the new data difficult to use. This is particularly true since the original data has significant shortcomings, and there is no reason to assume the same issues are not present in the new data. Therefore the NPCC Sixth Plan savings estimate of 6.0% of total electric and 2.1 kBtu/ft^2 gas will be used for the full potential of commissioning savings. These are conservative values.

These whole building savings numbers were transformed into savings fractions for the HVAC and lighting end uses. This allows savings to be better allocated to various building types and heating fuel types. The transformation requires estimates of end use fractions. The California End Use Study (CEUS) provides a detail estimate of California building end use splits. Since the whole building savings estimates are heavily dominated by California buildings, this was used to transform the whole building savings estimates to end uses savings estimates.

HVAC is assumed to dominate electric savings, as one key study attributed only 6% of savings to lighting. The lighting end use was assumed to account for 15% of the electricity savings. From CEUS the average end use fraction for HVAC gas is 0.36 and for HVAC electricity is 0.325. These calculations lead to an estimated savings of 22.4% of HVAC gas use, 15.7% of HVAC electric use, and 3.1% of interior lighting electric use. These savings primarily represent owner chosen third-party commissioning of complex buildings.

Previous regional code evaluations have assumed the current WSEC code-driven commissioning will achieve 15% of the full savings documented in a regional evaluation of third-party commissioning (similar to the NPCC Sixth Plan savings estimate). This arbitrary adjustment was applied to all building types. In this work code-driven savings are assumed to save 25% of the NPCC Sixth Plan savings estimate.

2010 OEESC to Oregon Reach

The 2010 OEESC required system test and balance (TAB) of the air and hydronic systems and basic system manuals for all buildings. The Oregon Reach Code requires TAB and explicit commissioning requirements for the mechanical, lighting, DHW, and renewable energy systems in all buildings.

The requirements are specific, requiring: a commissioning plan by a design professional for buildings >50,000 ft^2 with complex systems, system test and balance including a step to minimize throttling losses, functional testing of equipment, control sequences and equipment, preliminary commissioning report, and plans and manuals. A final commissioning report is required only if the post occupancy elective is being pursued. The functional testing for the lighting system is extremely specific.
2009 IECC to 2012 IECC

The 2009 IECC required system test and balance (TAB) of the air and hydronic systems and basic system manuals for all buildings. The 2012 IECC requires TAB and explicit commissioning requirements for the mechanical and lighting systems. Mechanical systems in buildings with total cooling capacity less than 480,000 Btu/h and heating capacity less than 600,000 Btu/h are exempt from the mechanical requirements, as are single-zone systems serving dwelling and/or sleeping units. This roughly corresponds to a 16,000-ft^2 building. These exempt systems are no longer required to be tested and balanced.

The requirements are specific and similar to the Oregon reach, requiring: a commissioning plan by a design professional, system test and balance including a step to minimize throttling losses, functional testing of equipment, control sequences and equipment, preliminary commissioning report, plans and manuals, and a final commissioning report. The lighting controls are to be functionally tested, but there is a little less specificity than the Oregon Reach.

2009 WSEC to 2012 IECC
The 2012 IECC language is very similar to the WSEC language with the exception that lighting commissioning is much more clearly required in the IECC. Due to the impossibility of assigning savings for language changes, this code change was considered to be energy neutral.

Cost Estimate
The requirements of the two codes are different, but given the vagaries of determining energy savings and costs for commissioning in general, they are evaluated the same. Cost data is derived from the NPCC Sixth Plan estimate of \$1/ft^2. The value was derived from field studies of largely incentivized new building commissioning. In this work, code driven commissioning savings are assumed to be only 25% of the incentivized counterpart. Costs are also assumed to be 25% of the incentivized value. Inflated to 2012 dollars results in a cost of \$0.266/ft^2.

Removed Washington Provisions
Many provisions of the WSEC are not included in the 2012 IECC. To assess the relative performance of the two codes, several of these provisions have been evaluated. Much of the material here comes from previous work (Kennedy, 2011).

Automatic Daylight Controls (2009 WSEC to 2012 IECC)
The 2009 WSEC requires all side and top daylight zones to have separately controlled primary and secondary areas with automatic daylight controls. Exempt are retail spaces adjacent to vertical glass, small spaces <300 ft^2 with OS control, conference rooms with multi-scene controller and OS, and HID lamps <100 watts. The automatic daylight controls are required to have continuous dimming to 20% light output, or step dimming with one

step for each lamp of a luminaire and automatic off, or step dimming reducing the output of all lamps in a fixture, with one step of at least 50% reduction and one to off. HID lamps which can be automatically step-dimmed to 50% power do not need to step to off.
The 2012 IECC requires automatic daylight control in fewer areas and also does not require step dimming to include an off step. The primary difference is the number of spaces required to have daylighting.

The evaluation of this measure is done in two steps. Calculations are made to remove savings for the current top and side daylight requirements in worksheets "TopDaylight (WA)" & "SideDaylight (WA)"), and then savings from the 2012 IECC daylight controls are included. Extensive documentation of the TopDaylight and SideDaylight calculations are presented in the 2011 NEEA Energy Code evaluations (Kennedy, 2011).

Cost data from this measure is derived from the NPCC Sixth Plan for a combination of step and continuous dimming. Costs were developed by building type. Continuous dimming was assumed for all side daylight controls and for all top daylight in health, lodging, office and restaurants, and 25% of the top daylighting in other building types.

Egress Light Controls (2009 WSEC to 2012 IECC)
The NEEA New Construction Survey found significant amounts of emergency circuit lighting on 24 hours a day, particularly in larger facilities with diverse schedules such as large and medium office, and schools.

The Washington code requires automatic shutoff of all lighting except as exempted. Generally, egress lighting is not exempted, although there is some concern that exemption 1, "Areas that must be continuously illuminated (e.g., 24-hour convenience stores)," may be used to exempt exit lights, but that certainly was not the intent of the code process. The 2012 IECC exempts this lighting.

The energy increase from removing this requirement is assumed to be 4% of overall building lighting energy. This results in savings slightly less than recent calculations done for the Title 24 in California. While all egress lighting will need to be controlled, savings are included only for medium and large offices and schools. Other buildings have 24-hour lighting in corridors (hospital and lodging) or have lighting that all goes out with a security system relay (retail, grocery, restaurant, warehouse).

California evaluated egress controls (California Utilities, 2011) for Title 24 and found them cost effective. Two scenarios of varying sophistication were evaluated for savings and cost. The first scenario involved control of only egress lighting, and scenario two included the control of emergency lighting not normally off. Savings were determined to be 0.16 kWh/ft^2 and 0.23 kWh/ft^2 for the scenarios respectively. The lower savings value is on the upper edge of estimates made in this evaluation, so costs for this less-intensive scenario are used. The cost estimates ranged from \$0.07 for large office to \$0.09/ft^2 for small office; \$0.08/ft^2 was used for this work.

Grocery Heat Recovery (2009 WSEC to 2012 IECC)
WSEC provisions require most grocery buildings to install equipment to recover refrigeration condenser heat and use it for water AND space heat. If the facility has food service and >500 kBtu remote refrigeration, then HR to water or space heat is required. If

the facility >40,000 ft^2 and has >1000 kBtu of remote refrigeration, then HR to both space and water is required. The 2012 IECC does not require grocery refrigeration heat recovery. In this evaluation, grocery HR has be treated briefly. Heat recovery is assumed to save 90% of the water heat and 75% of the space heat. Estimates of space and water heating energy are derived from the simulations. Applicable floor area and current heat recovery saturation were derived from the NEEA New Construction Survey. Seventy-five percent of the floor area would be required to have heat recovery to water heat, and 88% of the floor area already has it. Seventy-two percent of the grocery floor area would be required to have heat recovery to space heat, while only 14% has it.

A cost of $1.14/$ft^2$ (year adjusted) was taken directly from the 2009 WSEC code proposal evaluation (Baylon et al. 2009) and are based upon evaluation of grocery conservation done for NEEA.

Exhaust Air Heat Recovery (2009 WSEC to 2012 IECC)
Washington changed from requiring ERV on systems >5000 CFM with outdoor air fractions >70% to requiring ERVs on any system with more than 5000 CFM OA and on systems serving rooms with more than 5000 CFM OA. This results in all big box retail being required to have heat recovery and potentially requires ERVs on most large systems, though a major exemption is added for "cooling only air handling units" unless minimum outdoor air is greater than 70%. Since this language does not use the word "system," this likely exempts many cold deck air handlers, or at least those without pre-heat. As with the previous code, labs with variable volume supply and exhaust terminals, and systems serving spaces with a heating set point <60°F are exempt. With required ventilation levels, stores and groceries with single rooms >20,000 ft^2 would need to have exhaust HR. Offices, storage, and other spaces below 30,000 ft^2 are assumed to not need HR. Washington groceries over 40,000 ft^2 are required to have refrigeration heat recovery to space heat and so would not need to do exhaust air HR. Therefore this measure was limited to the fraction of groceries between 30,000 ft^2 and 40,000 ft^2.

Energy recovery has been modeled in the school, hospital prototypes, and large retail prototypes. Sensible heat recovery with 50% efficiency was modeled for the heating mode only.

Not evaluated and no cost developed.

Single Zone VAV (2009 WSEC to 2012 IECC)
Washington adopted language requiring single or multiple fan systems serving a zone with total supply over 10,000 CFM to have VFD to reduce air flow to 75%. Requiring zones with multiple units to use the aggregate unit flows with the CFM threshold makes this measure applicable to a large number of spaces. The provision allows buildings to use designated ventilation units, with other units cycling on conditioning needs as long as the ventilation units do not exceed 50% of the total air flow. This is likely the common response to this measure in zones with multiple units. This measure has been simulated assuming a VFD and a reduction in heating and ventilation air flow to 75% of the design amount.

This is a standard factory feature on most package equipment. Currently the most expensive single-unit, single-zone system (information derived from a short phone survey) is $1075 per 10-ton unit. The 2012 ASHRAE 90.1 requires VFD on all equipment >=10 tons, so costs should quickly fall. Alternatively, rooms with several rooftop units can have designated

ventilation units and then have the remaining units cycle to meet heating and cooling loads. This can be accomplished with current equipment at no cost. Since this provision applies to systems and rooms over 10,000 CFM (approximately 25 tons) where larger equipment is likely or multiple units can be used, this measure is assumed to cost $0.10/ft^2.

Series Fan Powered Box (2009 WSEC to 2012 IECC)
The WSEC requires that series fan powered boxes have ECM motors; the 2012 IECC does not require this but does have fan power limits where the WSEC does not. It was decided to not evaluate this measure since the overall fan power measure is not being evaluated. No cost was developed.

Occupancy Sensor Damper Control (2009 WSEC to 2012 IECC)
Washington code currently requires occupancy sensor control of outside air dampers or zone fans in classrooms, gyms, auditoriums, and conference rooms greater than 500 ft^2. The 2012 IECC does not. This provision saves significant conditioning and fan energy. Closing zone dampers served by VAV systems will result in lower fan energy, as will situations where the OS control turns off zone fans.

This measure was previously evaluated as by Kennedy 2011. Savings from that work are used here with no new modeling. In that work, savings were modeled as 2-tier reduction in average outside air. Primary school outside air is assumed to be reduced 14% during eight primary occupancy hours and 46% during five early/late hours. Secondary school outside air is assumed to be reduced 14% during nine primary occupancy hours and 46% during four early/late hours. Fan energy is assumed to be reduced by 10%. Large gyms, auditoriums and conference rooms requiring outdoor air greater than 1000 CFM will be required to have DCV and are exempted from this provision. This control was found in a number, but not a majority, of the NEEA New Construction Survey projects, but the data on this point is poorly developed. Current saturation was deemed to be 25%. Classroom and conference room fractions were taken from the NEEA New Construction Survey lighting zone data.

The incremental cost of a dual relay OS is approximately $20. This needs to be integrated with zone damper controls, which are assumed to cost $80. One OS sensor per 900 ft^2 was assumed (typical classroom).

Night Damper Control (2009 WSEC to 2012 IECC)
Washington currently requires outdoor air dampers be closed during night conditioning and morning warm-up. The 2012 IECC does not. This is an important requirement in small systems where outdoor air dampers open any time the system cycles on for night conditioning or morning warm-up. This measure was modeled in small office and small retail. Night operations were assumed to have 5% damper leakage only. This control strategy is typical in larger equipment typical in other building types, so modeling was not done for other building types.

Costs are derived from the NPCC Sixth Plan, which used an incremental thermostat cost of $80 per thermostat with 3000 ft^2 of floor area per thermostat. Inflation to 2012 dollars results in a cost of $0.028/ft^2.

Economizer (2009 WSEC to 2012 IECC)
Washington implemented increased-efficiency requirements for small cooling equipment installed without economizer. This equipment is exempt from the economizer requirement in the IECC, and no additional efficiency is required. The WSEC requirement varies by equipment class, from 15% more efficiency for small DX equipment to 25% improvement for chillers serving chilled water terminals without economizer. The NEEA New Construction Survey found 6.3% of the cooled floor area was served by small equipment without economizer.

Savings for this measure were estimated as 15% of the cooling energy consumed for each building type. Many factors, positive and negative, are not accounted for here. The existing equipment is better than code, and in some cases may already surpass the 15% requirement. On the other hand the estimated cooling energy generally assumes economizer operation, so the base cooling energy is inappropriately low. In addition, up to an additional 3.5% of the cooled floor area is served by other classes of equipment that are impacted by these provisions. In some cases this will be equipment room data not requiring additional efficiency, but in others increased efficiency will be required.

Applicable floor area was derived from NEEA New Construction Survey data. No cost has been developed for this measure.

Appendix D. New IECC 2009 – IECC 2012 Prescriptive Requirements

IECC 2009 to IECC 2012 Prescriptive Path Changes			
Section	**Description**	**Comment**	**Evaluation Method**
Section C402 Envelope			
C402.2 Insulation Requirements	Upgraded opaque insulation and u-values. More insulation required for most roofs, walls, and slab floors.	Change results in significant improvement in code UA requirements for all buildings.	Envelope impacts evaluated in DOE2. Increment will be derived by applying component requirements to Baseline 2005 buildings.
C402.3 Window Performance Requirement	Change in window type categories and u-values. Skylight u-values and window and skylight SHGC unchanged. Also, reduces the maximum window from 40% to 30% unless 50% of floor area is in daylight zone with automatic control.	Degree of change is hard to assess since categories changed. Curtain wall was U 0.45, now would be "Fixed" with U 0.38. Non-metal was U 0.35 and now will be U 0.38 if fixed or U 0.45 if operable.	Envelope impacts evaluated in DOE2. Increment will be derived by applying component requirements to Baseline 2005 buildings.
C402.3.1 Maximum skylight area.	Allowable skylight area increase from 3% to 5% if area under skylights has automatic daylighting control.	Significant change to code. Incremental change from 3% to 5% will have diminished impact on daylight control savings and increased HVAC interaction.	Evaluate with daylighting requirements.
C402.3.2 Minimum skylight area.	Minimum skylight for zone 5 spaces >10,000 ft^2 under roofs with LPD >0.5 W/ft^2. Also requires automatic multi-level control.	Significant change to code but may not be so big over standard practice. The LPD limit likely excludes many warehouse spaces	Evaluate with daylighting requirements.
C402.4Air Leakage	Sealing language and air barrier with low air permeability materials required. Buildings can comply by using tested low leakage materials, assembles, or by building leak test showing leakage <0.40 cfm/ft^2 at 75 PA. Many other provisions for dampers and vestibules.	One data set of baseline leakage in general commercial buildings shows average leakage rate around 1 cfm/ft^2 at 75 PA. This is a very important measure. Not sure there is data to determine equivalence of the low leak material versus air test method.	Evaluated in DOE2 as change in infiltration.
C402.4.5 Outdoor intakes and exhausts in building envelope.	Diminished requirement. 2009 IECC required motorized dampers except for one- and two-story buildings. 2012 IECC requires motorized dampers only for intakes on buildings over two stories tall.	This looks like confusion in the editing process	Not evaluated
Section C403 Mechanical			
C403.2.1 Calculation of heating and cooling loads	References ASHRAE Standard 183 rather than Handbook of Fundamentals. Still allows "equivalent computational procedure."	May eliminate complete misuse of Handbook of Fundamentals procedures.	Not evaluated
C403.2.2 Equipment Sizing	System sizing now shall not exceed load calculation BUT have exceptions for backup systems/capacity and also for systems or spaces with multiple units of the same type.	Most buildings have multiple systems so this may have no impact.	Not evaluated

IECC 2009 to IECC 2012 Prescriptive Path Changes			
C403.2.3 HVAC equipment performance requirements – Tables C403.2.3(1) – (7)	Added the ASHRAE 2010 equipment requirements to take effect in 2011 and 2012, primarily impacting water-cooled AC and PTAC/PTHP efficiency requirements. Added IERR for several equipment classes that IECC 2009 had omitted for smaller air cooled and all water cooled AC. Also, increased boiler efficiency significantly by moving from ASHRAE 2001 values to 2010 values. Change to chiller footnotes means fewer lower temperature chillers will avoid efficiency requirements.	Water-cooled AC, PTAC/PTHP (standard size units) and mid-size boiler efficiency requirements shift from 4% to 10%.	Impacts evaluated in DOE2. Increment will be derived by applying code requirements to Baseline 2005 buildings.
C403.2.3 (8) Performance requirements - Heat Rejection Equipment	Added standard heat rejection equipment performance requirements.	Good practice. No idea of baseline. [future item to research]	Not evaluated
C403.2.4.3.3 Automatic Start	New Requirement requires all systems to have controls capable of automatically adjusting start time to bring space to temperature prior occupancy. (optimum start)	Hard to access as typical baseline operation is unknown. Could assign a reduction in on-time. Some increase from really early starts in mid-winter, and also from people who set the time close and don't mind it cool when they arrive.	Not evaluated
C403.2.5.1 Demand Controlled Ventilation	DCV threshold reduced from 40 to 25 occupants per 1000 ft^2.	Adds DCV to correctional facilities, conference rooms, museums, mall concourses, bowling alleys.	Evaluated
C403.2.6 Energy Recovery Ventilation Systems:	Zone 5 requirement is not changed from system >5000 cfm with >70% OA. Zone 6 changes from the zone 5 requirement to any system (>11,000 cfm/>30% OA, >5500 cfm/>40% OA, >4500 cfm/>50% OA, >3500 cfm/>60% OA, >2500 cfm/>70% OA, >1500 cfm/>80% OA). Additional exceptions have been added for systems where the largest exhaust source is <75% of the design outdoor flow and systems expected to operate at the above flows for ,<20 hours per week.	Very significant for small number of applicable areas. New exceptions might eliminate a large fraction of applications.	Not evaluated
C403.2.8 Pipe Insulation:	Changed from previous table to more detailed table from ASHRAE 90.1. Insulation requirements for steam piping and large diameter hot water piping are increased, and requirements for cooling and smaller diameter hot water piping are decreased.	Incremental changes; some more, some less.	Not evaluated
C403.2.10.1 Allowable Fan horsepower	Added language forcing single-zone VAV to still comply with the CV values. Adds major exemption for hospital, vivarium, and laboratory systems.	Single zone VAV language forces any single-zone VAV system to comply with the more aggressive CV system values. IECC does not require single-zone VAV, so the impact of this will be limited. Also, most single-zone installations seen during the NEEA New Construction baseline had minimal duct systems, so likely all meet these requirements. The IECC has no single-zone requirements, but other regional codes and ASHRAE 90.1 - 2010 have pretty aggressive requirements for single-zone VAV, thus the saturation will likely increase and the variety of situations expand. This language is prudent. The complex spaces exempted used engineering might and lots of special pressure allowances to overcome code officials, so real system change from these exemptions is likely small.	Not evaluated

IECC 2009 to IECC 2012 Prescriptive Path Changes			
C403.3.1 Economizers (simple path only)	Reduces maximum equipment size without economizer from 54 kBtu to 33 kBtu, and reduces limit of total capacity without an economizer from 40 tons to 25 tons. Added exemption for systems that operate <20 hours per week. This could be large exemption if units are operated with intermittent fan where the annual full load hours might be <1000. Added aggressive economizer change over control requirements, which if followed would be large change. Also, added very ambiguous language regarding integrated economizer that seems to eliminate the need in all single-zone applications.	Small number of units in 3- to 4.5-ton size range. Specification of ambient changeover is large charge. Not sure it will impact actual installation.	Not evaluated
C403.4.1 Economizers	Weird change here seems to drop language requiring economizer. Section now only specifies items economizers shall comply with. Presumably this is a mistake. Adds maximum pressure drop for water side economizer.	Maximum pressure drop for water economizers is good addition, but baseline is unknown.	Not evaluated
C403.4.2 VAV fan control	VAV system fan motor threshold, above which VFD required is reduced from 10 HP to 7.5 HP.	Very small number of systems in this size range.	Not evaluated
C403.4.7 Hot Gas Bypass	Added section limiting the use of hot gas bypass to modulate cooling capacity in equipment >90,000 kBtu.		Not evaluated
Section C404 Service Hot Water			
C404.5 Pipe Insulation	Added heat-traced systems to those requiring insulation on all piping. Previously insulation was required on only first 8 feet and that only if the heating device did not have an integral heat trap.	Heat trace systems are typically recommended to be insulated by the heat trace system equipment providers, so impact here is probably small.	Not evaluated
C404.6 Hot Water systems controls	Almost requires automatic circulation control based upon demand but allows "manual" reduction with ready access to controls. This sounds like the current arrangement with a switch on the wall by the hot water heater.		Not evaluated
C404.7 Pools	Small language changes. Increased required energy recovery efficiency above which pool covers are not required from 60% to 70%.	Most pools likely used this exception, but the typical level of recovery efficiency achieved is not well characterized, so impact of this change is uncertain. Small applicability.	Not evaluated
Section C405 Electrical Power and Lighting			
C405.2.1.2 Light reduction controls	Added exception so dual level controls are not required in daylight zones.	This measure interacts with the automatic daylighting, and savings for the automatic daylighting provisions will need to be adjusted to account for this.	Evaluated with automatic daylight provisions.
C405.2.2.1 Automatic time switch controls	Lower threshold for requirement for buildings >5000 ft^2 to all buildings. Added exception for lighting intended for continuous operation, and egress. Removed requirement for holiday scheduling.	Savings dependent upon occupant baseline. Smaller buildings likely had pretty good control of lighting, but that is speculation. Exception for continuous operation is open-ended and makes enforcement difficult.	Not evaluated
C405.2.2.2 Occupancy Sensor	New Requirement. OS required in ALL classrooms, meeting, conference, lunch, break rooms, private offices, restrooms, storage rooms and other enclosed spaces <300 ft^2 except corridors, stairwells, patient care areas, restrooms, and sleeping units, where safety would be endangered; lighting intended for continuous operation, emergency pathway lighting.	Significant addition. Savings somewhat diminished by interaction with previous requirements for dual-level switching and automatic time clock controls and by new automatic daylight control requirements.	Evaluated

IECC 2009 to IECC 2012 Prescriptive Path Changes			
C405.2.2.3 Daylight zone control	Does not require automatic daylight control but does add minimum requirements for automatic daylight and multi-level lighting controls. Turn down to at least 35% rated power required.	Daylight zoning previously required. Savings only come if automatic harvest or multi-level control are required or used as chosen option by some other part of code. Turn down is likely more conservative than standard practice. Section C402.3 allows more vertical and horizontal fenestration if automatic daylighting installed, and requires zone 5 spaces >10,000 ft^2 under roofs with LPD >0.5 W/ft^2 to have skylights with automatic multi-level control. If the efficient lighting system option in C406.3 is chosen, then warehouse is required to have 60% of floor area in daylight zone with controls, and retail is allowed an extra 0.1 W/ft^2 and office an extra 0.05W/ft^2 if 30% of the floor area is in daylight zone with automatic controls.	Evaluated
C405.2.3 Specific application controls.	Much more specifically requires secondary lighting systems such as display and task lighting to be separately controlled.		Not evaluated
C405.5.2 Interior lighting power	No change in required lighting using the Building Area method. BUT old space-by-space method and allowances has returned. In some cases, such as office, restaurant, and warehouse lighting, this allows much higher light levels. In other cases the values appear to be coordinated with the building area method values.	Less strict. Allows designer two code calculations so they can pick best path. Some fraction of projects that don't comply with the Building Area method will comply with the space-by-space and will avoid changes to increase efficiency previously required.	Not evaluated
505.5.2 Interior lighting power – Display light (Table - footnote a).	Display light allowance removed from the building area method and only allowed for the space-by-space method. Old allowance allowed extra 1000 W for building display light no matter the area or type. New allowance has extra 500 W for SPACE display light no matter the area or type. All other allowances are the same.	In most cases the building area and space methods will have the same retail area as one space, so this is a reduction in the overall allowed display light. However, this is a "use or lose it" budget, and most buildings install far less wattage than the maximum allowed, so the impact is not big on average.	Evaluated together with lighting power.
Section C406 Additional Efficiency Package (prescriptive path only)			
C406 Additional Efficiency Package	Building must have one of the following: • LPD per C406.2 (0% to 20% less than C405). Includes some requirements for automatic daylighting. • Renewables of 1.75 BTU/ft^2 or 0.5 W/ft^2. • Renewables of >3% of building mechanical, water, and lighting use. • Increased mechanical efficiency per C406.3 values. Not an option if equipment not listed or if listed values are not different from C406.3.		All options evaluated as independent options.
Section C407 Total Building Performance			
C407 Total Building Performance path	Main change is reference design excludes some of prescriptive requirements (C406) and to comply a building must show energy use 15% less than the reference design.	Significantly tougher than IECC. ASHRAE 2010 would be chosen by projects want to pursue the performance route.	Not evaluated
Section C408 Energy System Commissioning			
C408 Energy System Commissioning	Buildings with >40 tons cooling or 60 tons heating must provide evidence of mechanical system functional performance testing. Must	Significantly change, but applicability limited to buildings larger than 16000SF or so. Previously coils and zone terminals	Evaluated as fraction of model predicted.

IECC 2009 to IECC 2012 Prescriptive Path Changes			
	be TABed and have preliminary acceptance report. Drawings and manuals must have data about installed equipment and test procedures. Must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics, and control sequences for HVAC system.	were required to have balancing devices, and mechanical system manuals were required.	EUI based upon Sixth Plan savings estimate with a realization factor applied. Would like BPA input on realization factor.

Appendix E. 2012 Oregon Reach Code Changes from 2010 Oregon Code

Oregon Prescriptive Code Provision Changes 2010 to the Oregon Reach Code			
Section	**Description**	**Comment**	**Evaluation Method**
Metering and Automated Demand Response			
604.3 – Energy Distribution Design	Requires all energy distribution systems to be designed to facilitate sub-metering into HVAC, lighting, plug, and process. Requires "each primary circuit, panel, feeder, piping system or supply mechanism" to supply one energy use type and also that space and access be provided for sub-meters.	Probably a big change for some buildings, but circuits are often separated already. Savings would derive from better maintainability in that being able to sub-meter would allow better troubleshooting.	Not evaluated
604.4 - Building Fuel Metering	Requires metering capability of each fuel used and energy source. This includes metering of district heat and cool provided to the building. Utility meters must have data port to facilitate the collection of data, and electric meters must determine 15-minute peak interval usage. Meters must be connected to data acquisition system.	Pretty standard in new buildings except possibly the metering of district heat and cool. Savings would derive from accountability and better maintainability.	Not evaluated
604.5 – Sub-Metering	Buildings >= 70,000 ft^2 are required to sub-meter energy end uses. Meters must be connected to data acquisition system.	A big change. Savings would derive from better maintainability resulting from better information on where and how much energy is being used for particular tasks. Impacts on energy use from operational changes are much easier to identify.	Not evaluated
605 – Automated Demand Response	Non-hospital buildings >= 50,000 ft^2 are required to have: • An EMCS that integrates with the HVAC, lighting controls, and external Auto-DR signal • Implemented sequences to reduce peak heating or cooling HVAC demand by not less than 10% • Implemented sequences to reduce peak lighting by not less than 15% in offices	EMCS requirement that integrates with both end uses might lead to energy savings, though this is hard to quantify. The ADR capability requirements are significant to the extent that peak demand is valued.	Not evaluated
Envelope (performance path only requires compliance with 606.1.2 and 606.1.3)			
Table 606.1.1(1) - Building Opaque Envelope Requirements	Fairly aggressive opaque insulation requirements. Roof decks R30ci from R20ci. Metal frame walls have an extra R5ci.	Change results in significant improvement in code UA requirements for all buildings.	Envelope impacts evaluated in DOE2. Increment will be derived using component requirements applied to Baseline 2005 buildings.

Oregon Prescriptive Code Provision Changes 2010 to the Oregon Reach Code			
Section	**Description**	**Comment**	**Evaluation Method**
Table 606.1.1(2) - Building Window Requirements	Ten percent decrease in window u-values. Skylights u-values and window and skylight SHGC unchanged.	Change results in significant improvement in code UA requirements for all buildings.	Envelope impacts evaluated in DOE2. Increment will be derived using component requirements applied to Baseline 2005 buildings.
606.1.1.1 Shading Devices	Vertical fenestration within 45 degrees of the nearest west and south cardinal ordinates shall be shaded by permanent horizontal exterior projections with a *projection factor* >= 0.25. Exceptions include buildings with <20% WWR and buildings taller than five or six stories based upon wind exposure.	The window exposure categories are extremely variable, but in most cases buildings above six stories will be exempt. Buildings with >20% WWR are primarily offices, so this applies pretty exclusively to medium and small office. Also, the SHGC requirements are tailored to projection factor so buildings complying with this requirement are allowed to increase their SHGC, largely negating the impact.	Not evaluated
606.1.2 Air Leakage	Sealing language and air barrier with low air permeability materials required. Buildings larger than 20,000 ft^2 must be tested and have leakage <0.25 cfm/ft^2 at 75 PA.	One data set of baseline leakage in general commercial buildings shows average leakage rate around 1 cfm/ft^2 at 75 PA. This is a very important measure.	Evaluated in DOE2 as change in infiltration.
606.1.2.5 Vestibules	Extends vestibule requirement to spaces <3000 ft^2 if they are three-story or higher atriums, or have elevator or stair shaft doors serving three stories or more.	Smallish number of spaces though would have impact in high-rise multi-family where elevator lobby is typically very small.	Not evaluated
606.1.3 Minimum Skylight Area	Enclosed spaces >10,000 ft^2 with ceiling height >15 ft with LPD <0.5 W/ft^2 and used for most purposes and under roof; must have 50% of area in daylight zone with a minimum of 3% skylights, and the skylight must have VLT >0.4. Skylights must not by >5% of gross roof.	Large number of spaces though saturation in retail and warehouse is high. Lighting controls language requires daylight harvest in daylight zones.	Evaluated. Possibly in DOE2 or with engineering calculation.
Mechanical (performance path only requires compliance with 607.3)			
607.1.1 Increased Building Efficiency	Building must have one of the following: • LPD 10% less than 609.1 • Renewables of 1.75 BTU/ft^2 or 0.5 W/ft^2 • Renewables of >3% of building mechanical, water, and lighting use • Increased mechanical efficiency, table 607.2.4 value or if not listed 10% better than federal standards	Don't really understand why this is in the mechanical section rather than specified as a group of electives with the others.	All three options evaluated as independent options.
Table 607.2.2.1 Ground Source Heat Pumps 503.2.3	Increase in efficiency of ~10%.	Very small saturation.	Not evaluated
607.3 Ventilation.	Requires system to be capable of reducing OA to OMSC chapter 4 or ASHRAE 62.1, sec 6.3 minimums. Also requires ERV if ventilation exceeds minimums of OMSC or 62.1 (no specifics on which section)	Interpreted this to be a confusing way to limit over-sizing of ventilation air. Baseline behavior here is unknown.	Not evaluated
607.4 Duct and plenum insulation, sealing and testing	Allowable leakage from high pressure ducts (>3.0") is reduces 33%. Allowable leakage equation is $F = CL \cdot P^{0.65}$ where CL = 4 and P = pressure. F is cfm/100 ft^2 duct surface. Old CL is 6.	Impact limited by saturation of high-pressure ducts. Typical leakage rates found in current testing is uncertain.	Not evaluated.

Oregon Prescriptive Code Provision Changes 2010 to the Oregon Reach Code			
Section	**Description**	**Comment**	**Evaluation Method**
607.5 Piping Insulation	Increases steam pipe insulation requirement for most pipe sizes. Decreases or increases hot water pipe insulation depending upon pipe size.		Not evaluated
607.6 Economizers	Fairly similar economizer language, though statements related to integrated operation and mixed-air control seem confused and could easily be interpreted as not requiring integrated economizer in any single-zone situations, even in units with staged compression. Language requiring a maximum pressure drop associated with water side economizer is new and a good addition.	Integration is significant issue between 7.5 and 15 tons where most equipment has staged compression. Most units 10 tons and greater likely have integrated economizer anyway. This new language is a step backwards. Water side economizer is less common and existing pressure drop baseline unknown.	Not evaluated
607.6 Economizers	Specifies high limit shutoff set points for economizer.	Model will show good savings from this but whether the system will run with this setting is uncertain.	Not evaluated
607.7 VAV systems	VFD threshold reduced from 10 HP to 1 HP, pressure reset on warmest zone required, only minimum ventilation is allowed to be reheated, and OA intake must be automatically reduced in response to change in system ventilation efficiency per ASHRAE 62.1, appendix A.	Very few VAV systems with motors <10 HP so that provision will not be evaluated. Pressure reset is currently required so IF building has DDC zone level control. This language will force this control strategy into new areas. Reheating only the minimum ventilation air seems kind of impossible. This would force a secondary heating system in many cases. I can't believe that this will be enforced. The controls will have this ability, but will they run that way is the question. OA intake reset is an interesting issue.	Research how minimum reheat will be enforced. And look for information on the OA intake reset. Possibly evaluate.
607.8 Kitchen Exhaust	Specifies the hoods shall follow OEESC and Reach and then has language that either does very little or directly contradicts the OEESC, depending upon how it is read.	Possibly decreases energy efficiency for the sake of improved ventilation efficiency.	Not evaluated
607.10 Hotel / motel guest room controls	Requires control to set back heating and set up cooling when units are unoccupied.	Language does not distinguish between unoccupied temporarily and unoccupied because the room in not rented. If OS control then this would be significant impact. If only during scheduled unoccupied then savings will be smaller since in many cases the heaters are turned off by the staff.	Not evaluated
Section 608 Service Water Heating Systems			
608.2 Equipment Efficiency, 608.7 Pipe Insulation, 608.8 Circulation System	Same equipment efficiency requirements. Pipe insulation is decreased for pipe diameters <1" and increased for those larger. Intent of circulation language unchanged.	Very small if any savings from these changes, though applicability is wide	Not evaluated
608.5: Future Solar	Plumbing, electrical, and controls shall be constructed to provide for future installation of a solar hot water system.	Lots of work. May or may not have savings. Definitely incurs an embedded energy deficit.	Not evaluated
608.6: Waste Water HR	Waste water heat recovery is required in laundries. System must preheat all incoming water used for hot water functions by not less than 10°F.	Good addition with significant savings but limited applicability.	Not evaluated
Section 609 Lighting			

Oregon Prescriptive Code Provision Changes 2010 to the Oregon Reach Code			
Section	**Description**	**Comment**	**Evaluation Method**
609.1: Interior Lighting Power	Across-the-board decrease in allowance (~10%), with LPD values approaching ASHRAE 2010.	Big change.	Lighting impacts evaluated in DOE2. Increment will be derived using lpd requirements applied to Baseline 2005 buildings.
609.2: Sleeping Unit Controls	Sleeping Unit Controls. Requires control system with occupancy detection to control all permanently wired lights.	Baseline highly uncertain. How many lights are left on? Applicability is limited outside of the lodging sector.	Not evaluated
609.3 OS Lighting Control	Requires OS control to reduce storage and stack lighting by at least 45%. Exception for systems with time clocks might eliminate most situations.	Savings significant, but applicability limited to warehouse and storage, and time clock exception might further reduce the population.	Evaluated
609.4 Exterior Light Control.	Requires total exterior light power reduced to 30% within two hours of operations concluding (except H and I occupancies), and building façade and sign shut down within one hour. If operations are continuous then building facade and sign shall be off between midnight. and 6 a.m.	OEESC lets light be designated as 24 hour. ORC eliminates this latitude. In smaller buildings this could be significant, but in rural areas lights might all be turned off with a switch to a much greater degree that required here.	Not evaluated
609.5 Automatic Daylight Control	As in OEESC but with a few additional exemptions for things such as "sidelight daylight zones where the vertical fenestration is located in an obstructed exterior wall."	Should just eliminate cases that won't have enough light to justify controls but likely will allow some buildings that would have benefited to avoid this section. Good addition; no or possibly negative energy savings.	Not evaluated
609.6 Plug Load Controls	Requires at least 50% of 120V receptacles in private offices and computer classrooms to have an automatic control device based upon schedule, OS, or signal from another control or alarm systems. Exception for receptacles equipped with portable occupancy sensor or time-clocks (read: power strip with OS).	Savings uncertain. Applicability restricted and savings baseline very uncertain with equipment getting much better in powering down. More research needed.	Not evaluated
609.8 Electrical System Efficiency	Adds several transformer efficiency tables with higher performance requirements for certain classes of transformers.	Small applicability. More research needed.	Not Evaluated
Section 610 Specific Appliances			
610.2.1 Elevators	Adds elevator motor, lighting, and ventilation efficiency requirements and stand-by mode.	Needs more research.	Not evaluated
610.2.2 Escalators	Adds escalator motor and lighting efficiency requirements and stand-by mode.	Needs more research.	Not evaluated
610.2.3 Commercial Food Service Equipment	Requires 50% of food service equipment to be EnergyStar eligible.	Needs more research.	Not evaluated
610.2.1 Conveyors	Adds conveyor motor sizing, and sleep mode requirements.	Small applicability.	Not evaluated
Section 611 Renewable Energy (this is a mandatory requirement)			

Oregon Prescriptive Code Provision Changes 2010 to the Oregon Reach Code			
Section	**Description**	**Comment**	**Evaluation Method**
611 Renewable Design	All prescriptive buildings must be designed with space, clearances, and structure to accommodate at least one renewable system capable of producing 2% of total calculated (performance) or estimated (prescriptive) energy use. For prescriptive, minimum renewables design must provide 1.75 Btu/hr or 0.5 W/ ft^2.	No direct energy savings.	Not evaluated
Section 612 Commissioning			
612 Commissioning	Must provide evidence of mechanical system functional performance testing. Must be TABed and have preliminary acceptance report. Drawings and manuals must have data about installed equipment and test procedures. Buildings >50,000 ft^2 must have commissioning plan and a systems manual with systems maintenance and calibration info, wiring diagrams, schematics and control sequences for HVAC, lighting, DHW, and renewable system.	Savings for code-mandated commissioning uncertain, particularly for small, simple buildings.	Evaluated as fraction of model predicted EUI based upon Sixth Plan savings estimate with a realization factor applied. Would like BPA input on realization factor.

Appendix F. Changes from 2009 Washington State Energy Code to 2012 IECC

The structural and categorization changes involved in switching from the 2009 Washington State Energy Code (WSEC) to the 2012 IECC result in a large number of changes between the codes. The changes involve dropped and diminished requirements in addition to strengthened requirements typical of same-code transitions. Due to the number of changes, many small aspects may be missing from this compilation. The organization is based upon 2012 IECC section numbers except where no IECC Section exists. Requirements of the 2009 WSEC that are dropped with no comparable IECC requirements are colored in rose.

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
Metering (2009 WSEC originally included metering requirements, but chapter has been suspended. Changes here assume metering is included in 2009 WSEC.)			
Whole building metering (WSEC 1201)	Dropped requirement. Previously whole building totalizing meter required for each energy source.	Thoughts on WSEC language: Great addition to eliminate campus nightmares. Savings will come from better, more targeted O&M.	Not evaluated
Automatic meter reading (WSEC 1202)	Dropped requirement. Previously whole building AMR totalizing meter required for each energy source for buildings with either: electric service >500 kVA OR gas or steam service >1000 kBtu/hr.	Thoughts on WSEC language: Great addition to eliminate campus nightmares. Savings will come from better, more targeted O&M.	Not evaluated
Sub-metering (WSEC 1203)	Dropped requirement. Previously "master sub-metering" required for buildings that meet AMR threshold and also have individual subsystems meeting secondary criteria.	Thoughts on WSEC language: Savings will come from better, more targeted O&M.	Not evaluated
IECC Chapter 3 General Requirements			
C301.3 / WSEC 1303 Climate Zones	IECC divides state into three zones: 4C, 5B, and 6B. Zones 4C and 5B have the same code provisions and can be treated as one zone. Zone 6B (Ferry, Okanogan, Pend Oreille, Stevens) has significantly different envelope and mechanical requirements.		Each zone evaluated.
C303.1.3 / WSEC 1312.1 Fenestration Rating	2012 IECC unlabeled fenestration default u-values very coarse. Assigned u-values for clear windows are lower than current WSEC; for low-e windows u-values are higher.	Pretty big difference. IECC table has no windows that pass the prescriptive code, so it pretty much forces a majority of windows to be labeled or other components to be upgraded to compensate. The broader WSEC table, which accounts for low-e, is better and offers at least a few options that comply.	Not evaluated
Envelope			
WSEC 1310.2 Semi-Heated Spaces	Dropped requirement. WSEC exempted semi-heated spaces from wall insulation requirements.	Likely energy savings from dropping this.	Not evaluated
WSEC 1310.3 Cold Storage and Refrigerated Spaces	Dropped requirement. Established minimum insulation levels for cold storage and refrigeration areas. Depending upon interpretation, could include walk-in refrigeration but seems limited to refrigerated warehouses. Now projects will have greatly reduced insulation requirements.	Large change in requirements. The 2012 IECC does not specify insulation for the demising walls and would require exterior walls to comply only with standard envelope minimum insulation levels. Standard practice is uncertain. Population, if limited to refrigerated warehouse, is limited.	Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
WSEC 1313 Moisture Control	Dropped requirement		Not evaluated
C402.2.4 Thermal resistance of below grade walls	Diminished requirement. IECC requires insulation to extend downward 10 ft. WSEC requires it for all below grade walls.	A step backwards.	Not evaluated
C402.2.8 Insulation of radiant heating systems	New requirement. Something about radiant floor insulation. I think it must be meant to be the back side insulation, but it is not clearly stated.		Not evaluated
Table C402.1.2, C402.2 Opaque Envelop	Increased requirement. Non-mass wall and roof requirements are the same to slightly less, mass wall values require twice the insulation, CMU with integral is not deemed, so requires more than twice the insulation; floor values are lower, particularly for heated slabs.	IECC overall is stronger. IECC opaque requirements lag the WSEC slightly, except the mass wall requirements, which far exceed the WSEC.	Evaluated by apply requirements to Baseline buildings.
Table C402.3 Fenestration	Changed requirement. IECC requirements based upon whether the window is fixed or operable while WSEC categorizes by frame material and window type (curtain/store front vs. all other). For non-metal frames WSEC is U0.32 while IECC is U0.4. For metal curtain wall WSEC is U0.4 and IECC is U0.38.	Comparable.	Evaluated by apply requirements to Baseline buildings.
C402.3.1 Maximum Fenestration Area	Changed requirement. WSEC allows 40% WWR and includes the skylight area in with the wall area. IECC allows 30% WWR and 3% skylight area. If 50% of the floor area is in daylight zones with automatic control, then IECC allows 40% WWR. If daylight control, then IECC allows 5% skylight.	Hard to compare. The WSEC already requires daylight in ALL daylight zones so the energy savings from the daylighting for the higher glazing fraction are already captured in the WSEC.	Evaluated by apply requirements to Baseline buildings.
C402.3.2 Minimum Skylight Area	New requirement: IECC requires minimum skylight for zone 5 spaces >10,000 ft^2 under roofs with LPD >0.5 W/ft^2. Also requires automatic multi-level control.	Significant change to code, but may not be so big over standard practice. The LPD limit likely excludes many warehouse spaces	Evaluate with daylighting requirements.
C402.3.3.3 Increased Skylight SHGC	Changed requirement. IECC allows skylight SHGC to be 0.60 (from 0.40) if lights beneath it have automatic daylight controls. WSEC states skylights should be 0.35.	Seattle has a reduced SHGC requirement for plastic domed skylights meeting a list of criteria.	Not evaluated
C402.4Air Leakage (WSEC 1314.1)	Changed requirement. IECC has much more specific sealing language and requires an air barrier with low air permeability materials everywhere. Buildings can comply by using tested low leakage materials, assembles, or by building leak test showing leakage <0.40 cfm/ft^2 at 75 PA. WSEC does not require materials with low air leakage anywhere but requires testing in buildings over five stories.		Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
C402.4.5 Dampers	Diminished requirement. WSEC does not discuss building envelope openings in the envelope section. The language in the mechanical section addresses this topic. IECC requires motorized dampers for intakes and barometric damper for exhaust or relief. Mechanical systems are treated separately. WSEC requires most dampers to be motorized over two stories.	This looks like code error in the IECC. Exception 1.3 mentions exhaust and relief dampers, but with 1.1 they are not required anyway. In IECC 2009 they were required to be motorized	Not evaluated
C402.4.5 Dampers – Leakage	Diminished requirement: IECC allows leakage of 40 cfm/ft^2 for dampers with at least one dimension <24 inches. WSEC specifies 10 cfm/ft^2 for package equipment dampers.	Not clear these leakage rates apply to package equipment. If they don't, then there are no leakage requirements. Assuming they do apply to mechanical equipment, for most package equipment IECC requirement allows more leakage. For very large package equipment the IECC requirement is superior. Actual baseline leakage rates of typical equipment are uncertain and would determine which change is more significant.	Not evaluated
C402.4.7 Vestibules	New requirement: IECC requires vestibules for public doors opening into spaces larger than 3000 ft^2.		Not evaluated
WSEC 1323 Street Lever Retail, Single Glazing	Removed language leads to new requirement. IECC removes diminished requirements for street level retail windows and removes 1% single layer window allowance for "ornamental, security or architectural purposes" changed to for "security purposes and vestibules and revolving doors."	Small impact due to limited area of glass. Street level allowance is not so important now that code has projection factor adjustments.	Not evaluated
Mechanical			
C403.2.1, C403.2.2 Calculation of heating and cooling loads and equipment sizing	Changed requirement. IECC references ASHRAE Standard 183 and must account for load reductions from heat recovery. Equipment must not exceed calculation. Allows approved alternate method. WSEC limits simple path equipment heating capacity to <10 Btu/h per square foot of gross conditioned floor area, and installed space cooling equipment shall not exceed 15 Btu/h per square foot. WSEC complex system loads calculate per referenced procedure, and equipment can be no larger than 150% of load. Also requires cooling loads >300 tons to be met be VFD or staged cooling equipment.	WSEC simple path is pretty tight, but only very small projects qualify for this path. There is lots of potential, but the simple path thresholds are considerably below (half) what was found in the baseline and if seriously enforced will result in everyone using the complex path calculation procedure where this strict language is not present. Not sure which calculation method is best. Savings would come primarily from fan energy savings.	Not evaluated
C403.2.3(1-7), Equipment Performance	New requirements: Adds ASHRAE 90.1 2010 equipment requirements to take effect in 2011 and 2012, which primarily impacting water-cooled AC and PTAC/PTHP efficiency requirements. Change to chiller footnotes means fewer lower temperature chillers will avoid efficiency requirements.	Water-cooled AC, PTAC/PTHP (standard size units) and mid-size boiler efficiency requirements shift from 4% to 10%. Chiller change may not impact efficiency, as baseline is uncertain.	Impacts evaluated in DOE2. Increment will be derived by applying code requirements to Baseline 2005 buildings.

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
C403.2.3(4), Equipment Performance Furnaces and Unit Heaters	Deleted requirements: Removes WSEC requirement for gas fired unit heaters to have IID and vent damper.	This is very important change, but as of Aug 8, 2008, EPACT requires gas and oil unit heaters to have IID and vent damper or power burner, so this code provision has little impact one way or the other. ASHRAE footnotes for gas and oil unit heaters should be added to IECC table.	Not evaluated
C403.2.3.1 (WSEC 1411.2.1) Non-Standard condition centrifugal chiller.	Changed requirement. IECC uses new formula from ASHRAE 90.1 - 2010.	Not sure of impact. Limited to centrifugal chillers and unclear what baseline efficiencies are. Likely small impact, if any. Definitely should use new formula to stay in sync with rest of country.	Not evaluated
WSEC 1411.1 HVAC Equipment Performance Requirements – General	Deleted requirement. Limited capacity of air cooled chillers to 100 tons in plants or buildings with more than 500 tons capacity. Exception for equipment 10% better than code.	Only one building in the NEEA New Construction Survey has 500+ tons of cooling and air-cooled chillers >100 tons.	Evaluated with other equipment performance.
C403.2.4.1 Thermostatic Controls	Diminished requirement. Adds special language for perimeter heating systems that allows multiple zones to be controlled from single point. It would allow multiple floors with same exposure to be controlled from one thermostat. WSEC forces zoning by floor but doesn't have any language that would preclude calling an exposure a zone even if it is in different rooms.	IECC language is an open can of worms.	Not evaluated
C403.2.4.1.1 Heat pump supplementary heat	Diminished requirement. WSEC requires outdoor air lock out of supplemental heat when ambient is above 40°F. This has been shown to save energy.	Ideal control and sizing should eliminate the need to heating above 40°F, but often with temperature set back or manual control the supplementary heat is engaged when the heat pump would meet the load.	Not evaluated
C403.2.4.3.3 Automatic Start Capabilities	Enhanced requirement. Threshold for optimum start controls reduced from systems >2000 CFM to all systems.	Savings depend upon saturation of non-optimum start thermostats and occupant settings.	Not evaluated
C403.2.4.4 Dampers	Diminished requirement: IECC does not require motorized dampers on buildings under three stories, while WSEC does if system supply CFM is >5000. Also, IECC either does not have leakage requirements or allows leakage of 40 cfm/ft^2 for dampers with at least one dimension <24 inches. WSEC specifies 10 cfm/ft^2 for package equipment dampers.	For most package equipment IECC requirement allows more leakage. For very large package equipment the IECC requirement is superior. Actual baseline leakage rates of typical equipment are uncertain and would determine which change is more significant.	Not evaluated
C403.2.4.5 Snow melt system controls	New requirement. Requires automatic control to shut off system when pavement temperature is above 50°F and automatic or manual system to shut off system when the air temperature is above 40°F.	Good addition. Not high incidence in Washington and uncertain baseline controls.	Not evaluated
1412.4.1.1 Damper Controls	Deleted requirement of zero outside air during scheduled unoccupied times even when night cycling and optimum start enabled.		Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
1412.4.1.1 Damper Controls	Deleted requirement for occupancy sensor control of outside air dampers or unit fans for classrooms, gyms, auditoriums and conference rooms >500 ft^2.	This is significant deletion in these spaces.	Not evaluated
1412.6 Combustion Heating Equipment	Deleted requirement for unit heaters and furnaces with capacity >225,000 Btu/hr. to have modulating or stage combustion control.	Not sure about baseline. Most equipment in larger sizes seems to have staged control so this is not too big a loss.	Not evaluated
1412.9 Parking garage ventilation	Deleted requirement. Required all parking garages and loading docks to have automatic control system to operate ventilation based upon occupancy or air quality. Gas sensor control was required for all garage systems >8000 CFM. Loading docks could be controlled by a time clock.	Important measure. Population of parking garages is limited. A step backwards.	Not evaluated
C403.2.6 Energy recovery ventilation systems.	Diminished requirement. WSEC sums the flows of all systems serving a space and applies the CFM threshold to the space. IECC is by system. WSEC sets a 5000 CFM outdoor air threshold with no percentage threshold, thus big box retail is covered.	Better treatment of multizone systems but a big step backwards for single-zone equipment.	Evaluated
C403.2.7 Duct and plenum insulation	Diminished requirement. Eliminates need for insulation in indirectly conditioned and conditions spaces.	Impacts ducts in plenums and above drop ceilings. Eliminating insulation will have a negative energy impact but hard to quantify and probably not a large impact. Definitely a lot of duct in these categories, though.	Not evaluated
C403.2.7.1 Duct construction	Changed requirement. IECC specifies more types of low-pressure duct seams to be sealed but allows duct tape for low- and medium-pressure sealing. Washington bans duct tape as primary sealant. Both codes require testing of high pressure ducts. WSEC requires testing in buildings <5000 ft^2 where 25% or more of the ductwork is outside the heated envelope.	Low pressure leak testing is important but mostly limited to very small buildings with ducts in crawl space or attic. Most other commercial has insulated roof deck with ducts in the indirect conditioned space.	Not evaluated
C403.2.8 Piping insulation	Changed requirement. IECC requires more insulation on high-temperature pipes and less insulation on pipes with cooler liquids.	IECC values are the same as latest ASHRAE values and probably more in tune with actual energy savings. Incremental differences here are likely very small.	Not evaluated
C403.2.10 Air system design	New requirement. IECC establishes maximum fan horsepower per CFM. WSEC regulates motor efficiency.	Fan system power baseline is uncertain, making evaluation of this item difficult. WSEC motor ratings mostly apply to non-package equipment.	Not evaluated
C403.3.1 Economizers	Diminished requirement for single-zone equipment <33000 Btu/hr. IECC allows up to 25 tons of this equipment. WSEC allows up to 6 tons if cooling efficiency is +15%.		Evaluate
C403.3.1.1.2 Economizer Control signal.	Diminished requirement. IECC does not require economizer integration for any single-zone systems. Pretty weird language.	For the 50% of the package equipment 10 tons and larger this has a large impact on requirements, but most equipment is integrated, so actual change is probably none. WSEC requires integration everywhere, but there are really only savings in 7.5+ ton units with staged compressors.	Not Evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
C403.4.1 Complex path economizers	Changed requirement. Assuming IECC will require economizer (current language does not require one), language is pretty comparable. IECC requires air or water economizer in all complex path equipment (non-single-zone, single thermostat equipment) and sets maximum pressure drop associated with water side economizer at 15 feet. IECC also defines allowable control strategies. WSEC also offers economizer exemption for 40 tons of water-cooled equipment if the IPLV is 25% over code. WSEC also has explicit treatment of server rooms.	Performance neutral, though the allowed performance strategy table has aggressive high limit requirements. If these were actually used then there would be savings. Not clear installers will use suggested high limit values.	Not evaluated
1438 System Criteria	Deleted requirement. WSEC required ALL fans and pumps 7.5 HP and greater to have VFD unless it was not a factory option.	Large change. Pumps on variable loads and fans on situations where balancing can reduce flow have large potential to save energy. Unsure of how to calculate savings.	Not Evaluated
C403.4.2.2 VAV pressure reset	Change. IECC has specific language requiring zone-based pressure reset where there is DDC zone control. WSEC is not clear whether control is automatic, dynamic or whether it is something that happens at TAB. If interpreted as automatic then WSEC is broader, as it requires pressure reset even where there is not zone-level DDC.	Zone-based pressure reset is probably standard where there is zone-level DDC control. So IECC language likely does not push any buildings to do something new, but language is better than WSEC's. The WSEC language implies pressure reset should happen on some basis all of the time and so likely is pushing project design.	Not evaluated
C403.4.3 Hydronic systems controls. Part 1	New requirements. IECC requires single boiler systems over 500,000 Btu/hr to be multi-staged or modulating. Requires heat-cool two-pipe systems to have a 15°F dead band with time delay between modes while WSEC is silent.		Not evaluated
C403.4.3 Hydronic systems controls. Part 2	Diminished requirements. Both codes require isolation of plant equipment. WSEC also requires hydronic loops with more than three control valves and three or more pump system HP to be "designed for variable flow" with the ability to reduce flow by at least 50% and to have temperature reset. IECC requires one or the other.		Not evaluated
C403.4.3 Hydronic systems controls. Part 3 Heat Pump loops	New and diminished requirements. IECC requires 20°F swing between cooling tower and boiler operation. WSEC silent. IECC also requires HX between HP loop and cooling tower. WSEC requires at least a value, but allows flow for freeze protection. IECC requires zone valves on systems with >10 HP, WSEC on systems >5 HP.		Not evaluated
C403.4.4: Heat rejection fan speed control	Diminished requirements. For heat rejection equipment fans >7.5 HP IECC allows multi-speed or VFD; WSEC requires VFD.		Not evaluated
C403.4.5 Requirements for multizone systems	Changed requirements. IECC has old 30% or 300 CFM before reheat and exempts zones with special pressure relationships WSEC has detailed language similar to new 90.1 language (turn down to 20%, 300 CFM, or vent needs, with 5°F dead band. Then can start reheat and ramp up to 50% at max heat. Exempts zone with special pressure relationships if they have temp reset, sup/ret VFD, & specified occupied and unoccupied/low occupied air flows.	Not clear codes really impact the details of how the VAV systems are operated.	Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
C403.4.6 Heat recovery for service water heating (WSEC 1436.3 & 1445)	Diminished requirement. IECC exempts non-24-hour facilities, WSEC does not. IECC exempts facilities with condenser rejection capacity <6000 kBtu/h, WSEC <1500 kBtu/h, and IECC exempts facilities with water heating capacity <1000 kBtu/h, WSEC >250 kBtu/h.	This provision hits big new hospitals and, in the WSEC form, possibly hotels. Population uncertain but small. Loads involved are large, so savings significant. The incremental population is uncertain.	Not evaluated
1432.2.1 Supply Air Temp Reset in Systems serving multiple zones	Deleted requirement. WSEC required interior zones, and high-occupancy areas shall have maximum air flow sized to meet typical cooling loads with the higher reset air temperature.	Was great addition to WSEC. Required engineers to design possible critical zones so they don't force the whole system into a cold supply air temperature mode requiring lots of reheat. Hard to evaluate impact of removal or determine baseline, as this was only added to the WSEC in 2010 and it is hard to enforce.	Not evaluated
1432.3.1.1 Pump variable flow controls	Deleted requirement. WSEC specified allowable control strategies. For systems with >20 HP of pumping, required static pressure reset based upon valve position or zone demand.	Baseline uncertain. All DDC system required to do pressure reset. The >20 HP control requires pressure reset based on zone level info (DDC or no), so DDC is being promoted.	Not evaluated
1432.4 DDC Controls Capability	Deleted requirement. WSEC requires all complex systems with DDC controls and all buildings with total cooling capacity exceeding 65 tons to have ability to trend all control points and also a "demand response set point adjustment" ability to lower heating set point and raise cooling set point automatically in response to demand control signal.	No direct savings, but O&M likely more effective with trending ability. Also, this was another item pushing DDC control.	Not evaluated
1433 Economizers, Dedicated server rooms	Deleted requirement. WSEC added exception to allow 20 tons of cooling for server rooms without air economizer if equipment is 15% better than code or 0% to 5% better than code if equipment has waterside economizer.	IECC does not mention server rooms so may require economizers. WSEC increased-efficiency requirement from 10% to 15% for units that avoided it. Economizer would save more energy.	Not evaluated
1434 Separate Systems (Zone Isolation)	Deleted requirement. WSEC requires zones with special process temperature requirements and/or humidity requirements shall be served by separate air distribution systems from those serving zones requiring only comfort conditions;	Exceptions and standard practice minimize impacts of this.	Not evaluated
1433 Economizers, VRF Systems	Deleted requirement. WSEC had exception for VRF systems. Lots of requirements with intent that this path is energy neutral.	IECC requires economizer, so should be energy neutral.	Not evaluated
1436.2 Heat Recovery – Steam Condensate	Deleted requirement. WSEC requires condensate water recovery.	Uncertain baseline. Limited to small number of buildings connected to central steam systems.	Not evaluated
1436.1 Heat Recovery – refrigeration	Deleted requirement. WSEC required facilities with food service and >500 kBtu remote refrigeration to have HR. If facility >40,000 ft^2 and >1000kBtu remote refrigeration, then HR to space and water required.	This is significant requirement for most grocery buildings to have HR to both hot water and space heat. Dropping requirement will lead to increased energy use.	Evaluated
1437 Motor Efficiency	Deleted requirement. WSEC has tables of required motor efficiency levels and includes many motors in equipment.	Small requirement change for a possibly large population. Offset in air handlers by IECC limits on fan system horsepower.	Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
1437 Series Terminal Fan Motor Efficiency	Deleted requirement. WSEC required motors in series fan powered terminals to have motor with efficiency of 65% or better.	WSEC intent is to force ECM motors in series fan powered terminals. Other motors satisfying this are not known so will assume ECM. Offset by IECC limits on fan system horsepower.	Not Evaluated
1438.1.2 Centrifugal Fan Cooling Towers	Deleted requirement. WSEC limited centrifugal fan open cooling towers to 1100 GPM with a 10F delta T (~5000 kBtuh). Towers exceeding this must meet axial fan tower efficiency requirements.		Not evaluated
1438.3 Large volume fan systems	Deleted requirement. WSEC required a fan system or systems serving a zone or zone without separating walls with a total airflow >10,000 CFM to reduce airflow based on conditioning demand. Requires VFD or designated ventilation units in fleet situations.	This is a large impact measure. IECC miss on this is big omission. ASHRAE 90.1 - 2010 has a requirement starting in 2012 is considerably beyond even the Washington requirement.	Evaluate. Model in school multipurpose and large retail.
1439.1 Kitchen Hoods	Deleted requirement. WSEC required 50% of make-up to kitchens with >2000 CFM exhaust at to be heated no more than 60°F.	WSEC kitchen threshold meant this applied to most kitchens. Current thinking is some of the strategies used to meet the WSEC language do not provide good ventilation, so trend is away from requiring compensating hoods.	Not evaluated
1439.2 Laboratory Hoods	Deleted requirement. WSEC required heat recovery pre-heat of supply air for laboratory exhaust systems >5000 CFM unless VAV with 50% turndown. Provided formula for a combination of HR and VAV with lesser performance.	IECC requirement is based upon supply air volume and % OA fraction. WSEC language would have caught situations missed by that language. The WSEC combination formula allowed some flexibility in how to meet it. Overall energy impact between the two codes is probably very small.	Not evaluated
1460 Cold Storage	Dropped requirement. Established several requirements for systems serving cold and frozen storage areas with refrigerated warehouses.	Definite decrease in required efficiency, but small population and uncertain baseline.	Not evaluated
Section C404. Service Hot Water			
C404.2 Water Heater Efficiency	New requirement. Has ASHRAE 90.1 water heater efficiency table. WSEC relied upon the boiler efficiency requirements and water heater standards.	The IECC explicitly regulates the efficiency of water heating equipment. A big difference in code but not likely above standard practice. The listed hot water boiler efficiencies are lower in some cases than the space heat boiler requirements (WSEC) but use a different test standard so might be equivalent.	Not evaluated
C404.3 Hot Water Temperature Controls	New requirement. Water heater shall be provided with controls to allow a set point of 110°F (43°C) for equipment serving dwelling units and 90°F (32°C) for equipment serving other occupancies.	This may be capability of most equipment or not. Since this is control capability the impact is likely small.	Not evaluated
C404.6 Hot Water System Controls	Diminished requirement for circulation controls. IECC allows manual or automatic control, WSEC requires automatic control. Both codes are a bit ambiguous about basis. IECC mentions demand but allows manual control, WSEC requires automatic but specifies control during periods of "non-use."	Capability of time clock or other demand control is important in circulation systems in most building types, but circulation systems do not have significant saturation outside of residential and healthcare occupancies.	Not evaluated
C404.7.1 Pool Heaters	Changed requirement. IECC has specific pool heater requirements except for heat pump heaters. WSEC regulates boiler efficiency and requires heat pumps to have COP of 4.0 or better; other pool heaters are unregulated.	Small population. Heat pump is common heater type, so WSEC might have edge here.	Not evaluated

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
C404.7.3 Pool Cover	Diminished requirement. IECC requires vapor barrier cover unless 70% of heat is from site recovered source (HP typically in exhaust air or dehumidifying the room air), WSEC requires R12 cover always and requires exhaust air HR.	Small population. Vapor barrier is by far the most important aspect of cover, and thinner cover is likely used more often. IECC exception for site recovered allows many northwest pools to avoid cover.	Not evaluated
1455 Pool Heat Recovery	Deleted requirement. Pools with surface area >200 ft^2 shall have exhaust air heat recovery.	Small population.	Not evaluated
Section C405 Lighting			
C405.2 Lighting Controls	Diminished requirement. Exempt spaces are hard to interpret, but IECC exception for means of egress lighting potentially lets a very important lighting category out of having control. WSEC requires automatic shutoff except areas requiring 24 hours illumination and allows OS to do partial shutdown of light in stairwells.	Big change, though the WSEC 24 hour illumination exception could be used to exclude this same lighting	Not evaluated
C405.2.1.2 Lighting reduction controls (dual level)	New requirement for dual-level switching. Excludes spaces with LPD <0.6W/ft^2, or occupancy sensors or daylight controlled spaces.	Big change, except with daylight control mandated in WSEC, savings probably greatly diminished	Evaluated
C405.2.2.3 Daylight zone controls	Diminished requirement. IECC does not require automatic daylight dimming except for storage areas >10,000 ft^2 or when daylighting is chosen as an optional path for other areas of the code (higher LPD, increased WWR). For with WWR credit 50% of the floor area must be in controlled daylight zones.	WSEC has more stringent requirement, though energy impacts are difficult to assess with various tradeoffs in the IECC that may not be energy equivalent. Likely will assume buildings do not exercise tradeoff except for high glazing cases and warehouses.	Evaluated
C405.2.2.3.2 Automatic daylighting control Capabilities	Changed requirement. IECC requires controls to reduce lighting output to 35% with at least one addition step between 50% and 70%. WSEC requires controls to reduce lighting output to 20% (continuous dimming) or to OFF (step dimming) with at least one intermediate step at least 50%.	IECC step language is better for intermediate step but WSEC requirement for OFF is big and minimum turndown for continuous dimming systems also better. Marginal difference, not large, will impact large number of spaces in new codes.	Not evaluated
C405.5.1.3 Other luminaires (determining watts for)	Diminished requirement. IECC requires the use of the "wattage of the lighting equipment" WSEC requires the wattage to be that of the "maximum lamp".	Very significant difference if enforced. Almost all fluorescent fixtures are capable of driving lamps of a significant range of wattages. Maximum lamp might be 50% higher than the supplied lamp especially in can light situations	Not evaluated
C405.5.1.4. Line voltage track lighting.	Diminished requirement. IECC specifies a default minimum wattage of 30 watts per lineal feet of track, WSEC specifies 50 watts per lineal foot.	Baseline survey found more than 50 watts per lineal foot of track so IECC languages allows track without heads to be booked at a significantly lower wattage than the future average installed wattage.	Included in LPD evaluation.
Table C405.5.2(1) Building Area Lighting Power Allowance	Diminished requirement. For most building types IECC allowances are higher than WSEC.	Big change.	DOE2 simulation on average LPD from baseline buildings.

Washington Code Changes 2009 WSEC to 2012 IECC			
Section	**Description**	**Comment**	**Evaluation Method**
Table C405.5.2(2) Space Method Lighting Power Allowance	Diminished requirement. IECC provides alternative calculation that can be used if desired. The space allocations in many cases are significantly relaxed for the building method allowances.	Big change.	DOE2 simulation on average LPD from baseline buildings.
1540 Transformers	Deleted requirement.		Not evaluated
Section C406 Additional Efficiency Package Options (must choose one)			
C406.2 HVAC	Increased mechanical efficiency per C406.3 values. Not an option if equipment not listed or if listed values are not different from C406.3.	If chosen, equipment efficiency winds up beyond WSEC requirements.	DOE2 simulation on average UASF from baseline buildings.
C406.3 Lighting	Must use lighting table C406.3, which has only the building method and 0% to 20% less than C405. Includes some requirements for automatic daylighting in warehouse generally and in some other building types in exchange for slightly higher LPD allowances.	In chosen lighting LPD is reduced from WSEC	DOE2 simulation on average LPD from baseline buildings.
C406.4 Site Production	Renewables of 1.75 BTU/ft^2 or 0.5 W/ft^2, or renewables of >3% of building mechanical, water, and lighting use.		Evaluated. Engineering calculation.

Appendix G. Energy Savings by State, Code Provision, and Utility Type

Tables G1 through G3 present detailed unit energy savings and cost estimates by code provision and preference utility type for each state. This information can be used to isolate impacts of particular provisions. Generally there is very little variation by preference utility type

Table G1. ID/MT Energy Savings and Cost by Code Provision and Preference Utility Type

	Electric Savings (kWh/ft²)				Fuel Savings (kBtu/ft²)				Cost ($/ft²)			
	Preference Customer Type				Preference Customer Type				Preference Customer Type			
Code Item	SRR	PIL	PIH	All	SRR	PIL	PIH	All	SRR	PIL	PIH	All
Mandatory Provisions												
2010 Equipment Efficiency EER	0.001	0.002	—	0.002	0.000	0.000	—	0.000	0.000	0.000	—	0.000
Air Barrier	0.040	0.038	—	0.039	0.609	0.679	—	0.637	0.292	0.300	—	0.295
Automatic Lighting Controls	0.074	0.074	—	0.074	-0.083	-0.092	—	-0.086	0.022	0.019	—	0.021
Base Code Boiler Efficiency	0.000	0.000	—	0.000	0.367	0.306	—	0.343	0.000	0.000	—	0.000
Commissioning	0.114	0.129	—	0.120	0.686	0.832	—	0.744	0.166	0.174	—	0.169
Envelope Changes	0.152	0.140	—	0.147	1.274	1.450	—	1.344	0.405	0.398	—	0.402
LPD Changes	0.234	0.219	—	0.228	-0.168	-0.206	—	-0.183	0.022	0.020	—	0.021
Minimum Skylight Area	0.044	0.070	—	0.054	-0.068	-0.117	—	-0.087	0.119	0.130	—	0.124
Increased-Efficiency Options												
HVAC Equipment	0.053	0.049	—	0.051	2.105	2.668	—	2.329	0.541	0.668	—	0.591
Lighting – LPD component	0.363	0.477	—	0.409	-0.482	-0.673	—	-0.558	0.051	0.052	—	0.051
Lighting – Warehouse DL part	0.066	0.056	—	0.062	-0.089	-0.076	—	-0.084	0.148	0.124	—	0.139
Renewables – PV	0.327	0.372	—	0.345	0.000	0.000	—	0.000	1.591	1.820	—	1.682

Table G2. Oregon Energy Savings and Cost by Code Provision and Preference Utility Type

	Electric Savings (kWh/ft²)				Fuel Savings (kBtu/ft²)				Cost ($/ft²)			
	Preference Customer Type				Preference Customer Type				Preference Customer Type			
Code Item	SRR	PIL	PIH	All	SRR	PIL	PIH	All	SRR	PIL	PIH	All
Mandatory Provisions												
Air Barrier	0.036	0.036	0.033	0.035	0.482	0.543	0.356	0.463	0.302	0.318	0.307	0.309
Automatic Lighting Controls	0.104	0.089	0.087	0.093	-0.078	-0.083	-0.063	-0.075	0.041	0.030	0.035	0.035
Commissioning	0.139	0.165	0.163	0.156	0.708	0.814	0.856	0.792	0.247	0.248	0.245	0.247
Envelope Changes	0.261	0.271	0.198	0.244	1.702	1.759	1.207	1.562	0.596	0.615	0.536	0.583
LPD Changes	0.286	0.305	0.251	0.282	-0.335	-0.372	-0.280	-0.330	0.041	0.044	0.038	0.041
Minimum Skylight Area	0.065	0.070	0.041	0.059	-0.090	-0.110	-0.039	-0.080	0.117	0.109	0.083	0.103
Increased-Efficiency Options												
HVAC Equipment	0.077	0.093	0.090	0.086	1.523	1.735	1.829	1.695	0.738	0.823	0.683	0.750
Lighting – LPD	0.407	0.444	0.409	0.421	-0.316	-0.381	-0.360	-0.352	0.044	0.053	0.063	0.054
Renewables - PV	0.293	0.336	0.327	0.319	0.000	0.000	0.000	0.000	1.449	1.654	1.596	1.567
Project Electives[1]												
DHW Equipment	0.000	0.000	0.000	0.000	0.191	0.311	0.217	0.241	0.000	0.000	0.000	0.000
Envelope	0.063	0.067	0.052	0.061	0.483	0.509	0.393	0.463	0.282	0.300	0.274	0.285
Renewables PV1[2]	0.191	0.218	0.208	0.206	0.000	0.000	0.000	0.000	0.947	1.073	1.017	1.013
Renewables PV2[2]	0.149	0.176	0.203	0.176	0.000	0.000	0.000	0.000	0.764	0.891	1.005	0.885

1- If the HVAC and/or LPD is not used for Increased-Efficiency Option then it is available as project elective.
2- If the renewables Increased-Efficiency Option is not used then PV1 is the available elective, otherwise PV2 is the available elective.

Table G3. Washington Energy Savings and Cost by Code Provision and Preference Utility Type

	Electric Savings (kWh/ft²)				Fuel Savings (kBtu/ft²)				Cost ($/ft²)			
	Preference Customer Type				Preference Customer Type				Preference Customer Type			
Code Item	SRR	PIL	PIH	All	SRR	PIL	PIH	All	SRR	PIL	PIH	All
Mandatory Provisions												
2010 Equipment Efficiency EER	-0.002	-0.002	-0.003	-0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Air Barrier	0.019	0.018	0.017	0.017	0.297	0.267	0.219	0.235	0.250	0.272	0.251	0.254
Automatic Lighting Controls	-0.077	-0.062	-0.022	-0.034	0.034	0.030	0.006	0.012	-0.030	-0.020	0.015	0.005
Envelope Changes	0.029	0.042	0.050	0.046	0.262	0.321	0.324	0.317	0.123	0.123	0.173	0.160
LPD Changes	0.060	0.014	0.024	0.026	0.009	0.053	0.037	0.037	-0.002	-0.005	-0.004	-0.004
Minimum Skylight Area	0.045	0.049	0.036	0.039	-0.046	-0.047	-0.034	-0.037	0.137	0.126	0.093	0.103
Mandatory Provisions Eliminated												
Economizer	-0.004	-0.004	-0.006	-0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Egress Light Control	-0.026	-0.031	-0.035	-0.033	0.018	0.023	0.019	0.020	-0.018	-0.019	-0.027	-0.025
Night Damper Control	-0.005	-0.002	-0.001	-0.002	-0.135	-0.126	-0.084	-0.096	-0.005	-0.005	-0.005	-0.005
OS Damper Control	-0.019	-0.025	-0.022	-0.022	-0.448	-0.585	-0.514	-0.518	-0.005	-0.006	-0.006	-0.006
Grocery Heat Recovery	0.000	0.000	0.000	0.000	-0.378	-0.217	-0.237	-0.249	-0.013	-0.008	-0.009	-0.009
Side Daylight Controls	-0.150	-0.161	-0.185	-0.177	0.101	0.107	0.108	0.107	-0.108	-0.106	-0.129	-0.123
Single Zone VAV Required	-0.027	-0.033	-0.025	-0.026	0.075	0.093	0.067	0.072	-0.005	-0.006	-0.005	-0.005
Top Daylight Control	-0.052	-0.046	-0.051	-0.051	0.029	0.027	0.027	0.027	-0.009	-0.007	-0.012	-0.011
Increased-Efficiency Options												
HVAC Equipment	0.062	0.069	0.082	0.078	1.350	1.472	1.367	1.381	0.546	0.595	0.624	0.611
Lighting – LPD component	0.270	0.371	0.337	0.335	-0.314	-0.425	-0.381	-0.380	0.041	0.048	0.051	0.050
Lighting – Warehouse DL part	0.096	0.080	0.057	0.065	-0.067	-0.032	-0.019	-0.026	0.214	0.180	0.128	0.145
Renewables – PV	0.240	0.263	0.262	0.260	0.000	0.000	0.000	0.000	1.178	1.300	1.282	1.273

Appendix H. Memorandum: BPA Utility Adjustments to NPCC Nonresidential New Construction Floor Area Forecasts

To: Carrie Cobb
From: Mike Kennedy
Date: April 10, 2012
Re: BPA Utility Adjustments to NPCC Nonresidential New Construction Floor Area Forecasts

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The Northwest Power and Conservation Council (NPCC) regional floor area forecasts of future nonresidential new construction activity are segmented by building type and location (state). This data is used to estimate the impact of conservation programs targeting nonresidential new construction. Bonneville Power Administration (BPA) customers are a subset of these forecast regions, and past work has used a fixed-percentage adjustment across all floor area. Given the non-uniform distribution of nonresidential construction within the region and the variability of conservation savings by building type, an assessment of nonresidential construction in BPA urban and rural customer territories was undertaken.

The goals of this analysis are to:

- Further develop BPA methods to assign electric utility based upon address (zip code, city, county).
- Compare the assignment from those methods with the CBSA utility name data.
- Estimate new construction floor area by location (state), building type, and BPA customer type.
- Summarize basic characteristics for BPA customers from the CBSA data set.

This memo presents the new construction floor area fraction estimates for the BPA preference customer utility group. Attachment A presents multipliers to determine the portion of the NPCC floor area forecast occurring in BPA preference utility territories. Attachment B to this memo addresses the method development. Attachment C presents a comparison to CBSA floor area distribution and some basic CBSA summaries by customer group. Attachment D presents a listing of BPA regional utilities with rural and urban indicators.

BPA Preference Utility New Construction Floor Area Fractions

RW Dodge developed and maintains a database of all new construction in the region. RW Dodge data has been used many times in regional work to establish nonresidential new construction activity and develop recruiting lists for new building characterization. It has been found to be complete. RW Dodge new construction data for the period from 2002 through 2007 was acquired in previous work and formed the basis of the analysis here. The data included all regional nonresidential project starts as determined by RW Dodge. To develop an estimate of new construction floor area for BPA preference utilities, each project was assigned to a utility (or weighted set of utilities) based upon zip code, city, and/or county information. In cases where multiple utilities served the same geographical area, projects were assigned a weighted set of utilities.

Each utility was assigned to a BPA customer group. BPA distinguishes between:

- Preference utilities: public utilities that receive reimbursements from BPA for energy efficiency;
- Direct-serve Federal facilities: BPA provides many federal facilities direct services for energy efficiency upgrades; and
- Other utilities: IOU and public utilities that are not preference customers and do not receive reimbursements from BPA for energy efficiency.

Preference utilities are further classified as either small/rural/residential, urban, or suburban. Program Involvement - High[5] (PIH) utilities are utilities that have independent new construction conservation programs. They tend to be urban as well, and so they potentially have different building characteristics. Small/rural/residential utilities are those requiring less than 10 average megawatts, with fewer than 10 customers per line mile, and with greater than 66% residential load. These utilities do not have active commercial new construction programs. Program Involvement - Low (PIL) utilities are non-rural preference utilities that do not have active program offerings or designated staff.

Table 1 presents the percentage of new nonresidential floor area by state and BPA customer group. Preference utilities serve 38% of regional new nonresidential floor area. There is significant variation by state with preference utilities serving 53% of Washington floor area, but only 12% in Idaho, 34% in western Montana, and 23% in Oregon. According to the NPCC floor area forecast, the split of total floor area between states is similar to historic trends. However, in the future the Washington share of regional floor area is forecasted to increase, first to as high as 90% in 2012 and then trending down to around 61% starting in 2015. This will shift the portion of total regional floor area that is served by preference utilities as well. The BPA customer saturations found in this work should be applied on a state level so this change will be accounted for. This assumes that the distribution of floor area within each state will remain similar to the 2002–2007 period.

Table 2 presents the percentage of regional nonresidential floor area by state and preference utility type. This table is a detailed look at the Table 1 preference utility row.

Table 1. Nonresidential New Construction by State and Customer Group (% of Regional Floor Area)

Customer Group	ID	MT	OR	WA	Region
Preference Utilities	1.8	1.0	6.2	29.1	38.0
Other Utilities	13.1	2.0	21.2	25.2	61.4
Direct-Serve Federal Facilities	0.0	0.0	0.0	0.6	0.6
Total	14.9	2.9	27.4	54.8	100.0

[5] Program Involvement - High utilities are: Seattle City Light, Snohomish PUD, Tacoma PUD, Clark PUD, Eugene Water and Electric Board and Springfield Utility Board.

Table 2. Nonresidential New Construction by State and Preference Utility Type (% of Regional Floor Area)

Preference Utility Type	ID	MT	OR	WA	Region
Rural	1.5	0.2	2.0	3.3	6.9
Program Involvement - Low	0.4	0.8	2.1	4.5	7.7
Program Involvement - High	0.0	0.0	2.1	21.3	23.4
All Preference Utilities	1.8	1.0	6.2	29.1	38.0

Table 3 presents the percentage of preference utility new nonresidential floor area by state and preference utility type. PIH utilities serve 62% of new BPA preference utility floor area, PIL utilities serve 20.3% and rural utilities serve 18.2%. Idaho preference utility floor area is served primarily by rural utilities, while Montana preference floor area is served predominantly by PIL utilities. Oregon preference floor area is evenly split between rural, PIL and PIH utilities, while Washington preference floor area is served primarily by PIH utilities.

Seventy-six percent of preference utility new nonresidential floor area is in Washington State. Washington State includes nearly all floor area served by urban utilities, 57% (11.7/20.3) of the floor area served by suburban utilities, and 48% (8.7/18.2) of that served by rural utilities. If the NPCC forecast is correct that a larger portion of regional construction will occur in Washington, and construction is distributed within the states in the same way as the 2002-2007 period, the Washington portion of total preference floor area will increase to more than 80% over the next decade.

Table 3. Nonresidential New Construction by State and Preference Utility Type (% of Floor Area Served by Preference Utilities)

Preference Utility Type	ID	MT	OR	WA	Region
Rural	3.8	0.5	5.2	8.7	18.2
Program Involvement - Low	0.9	2.0	5.6	11.7	20.3
Program Involvement - High	0.0	0.0	5.4	56.1	61.5
All Preference Utilities	4.8	2.5	16.2	76.5	100.0

Table 4 presents the percentage of the regional building type floor area by BPA customer group. Between customer groups there is significant variation in the building type distribution. Preference utilities serve a larger fraction of regional hospital and health, K–12, university, and grocery floor area, and a smaller fraction of total office floor area. The health-care result is driven by Washington, where two of the major medical centers are served by Seattle and Tacoma utilities.

Table 4. Distribution of Nonresidential New Construction by Building Type and Customer Group (% of Regional Building Type New Floor Area)

Building Type – NPCC Categories	Preference Utilities	Other Utilities	Direct-serve Federal facilities	Total
Office - Med & Large	33.5	66.5	0.0	100.0
Office – Small	33.2	66.7	0.1	100.0
Retail - BB/Anchor	36.0	64.0	0.0	100.0
Retail - Small/HE	36.1	63.9	0.0	100.0
K–12	40.3	59.5	0.2	100.0
University	41.8	56.6	1.6	100.0
Warehouse	33.6	66.3	0.1	100.0
Grocery	44.8	55.2	0.0	100.0
Restaurant	29.7	70.3	0.0	100.0
Lodging	39.3	58.7	2.0	100.0
Hospital	52.9	47.0	0.1	100.0
Other Health	44.7	55.3	0.0	100.0
Assembly	34.8	64.4	0.8	100.0
Other	41.4	55.5	3.2	100.0
Total	38.0	61.4	0.6	100.0

Table 5 presents the distribution of total preference utility building type floor area by preference utility type. This table is a detailed look at the Table 3 preference utility column. There is significant variation in building type distribution between preference utility types. Of the medium and large office floor area served by preference utilities, 9% is served by rural utilities, 4% by Program Involvement - Low utilities, and 87% by Program Involvement - High utilities. This can be compared with the distribution for all preference floor area (18%, 20%, and 62% respectively) to provide perspective on the differences between the preference utility types. Hospital and Other Health floor area presents a similar urban trend while K-12 and University floor area present the opposite trend.

Table 5. Distribution of Nonresidential New Construction in Preference Utilities (% of Preference Utility Building Type Floor Area)

Building Type – NPCC Categories	Rural	Program Involvement – Low	Program Involvement – High	All Preference Utilities
Office - Med & Large	9	4	87	100
Office – Small	20	20	59	100
Retail - BB/Anchor	16	30	55	100
Retail - Small/HE	16	20	64	100
K–12	22	25	53	100
University	22	32	46	100
Warehouse	21	20	58	100
Grocery	22	22	57	100
Restaurant	13	26	61	100
Lodging	9	29	62	100
Hospital	11	15	74	100
Other Health	10	15	75	100
Assembly	23	23	55	100
Other	30	14	56	100
Total	18	20	62	100

Table 6 presents the distribution of floor area for each building type within the different customer groups. This is another view of the floor area distribution by building type. Medium and large offices account for 9.8% of regional floor area but only 4.3% of the floor area served by preference rural utilities.

Table 6. Distribution of Nonresidential New Construction by Customer Group (% of Total Customer Group Floor Area)

Building Type – NPCC Categories	Preference utilities				Other Utilities	Direct-Serve Federal facilities	Total Region
	All	Rural	PIL	PIH			
Office - Med & Large	8.7	4.3	1.8	12.2	10.6	0.0	9.8
Office – Small	5.8	6.5	5.9	5.6	7.2	1.4	6.7
Retail - BB/Anchor	12.1	10.4	17.8	10.8	13.3	0.0	12.8
Retail - Small/HE	3.9	3.4	3.9	4.0	4.2	0.1	4.1
K–12	12.4	15.2	15.4	10.6	11.3	4.5	11.7
University	3.6	4.4	5.7	2.7	3.0	9.4	3.3
Warehouse	13.5	15.8	13.6	12.8	16.5	3.1	15.3
Grocery	2.6	3.2	2.8	2.4	2.0	0.0	2.2
Restaurant	0.8	0.5	1.0	0.8	1.1	0.0	1.0
Lodging	4.5	2.3	6.4	4.6	4.2	15.7	4.4
Hospital	5.8	3.6	4.2	7.0	3.2	0.4	4.2
Other Health	9.2	5.3	6.8	11.1	7.0	0.2	7.8
Assembly	6.5	8.1	7.3	5.8	7.4	10.1	7.1
Other	10.6	17.2	7.4	9.6	8.8	55.1	9.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Attachment A. BPA Preference Utility Multipliers

The NPCC forecasts regional new nonresidential floor area by state and building type. Tables A1 through A4 provide multipliers that are appropriate for combination with the NPCC floor area forecast to determine forecast floor area served by BPA Preference utilities. Each cell is the percent of floor area forecast for that state and building type that is served by the specified utility type. Table A1 presents the fraction of a given state and building types 2002–2007 nonresidential new construction floor area that is served by Preference utilities.

Table A1. Fraction of Forecast Floor Area Served by Preference Utilities (Fraction of State/Building Type Forecast Floor Area)

Building Type	ID	MT	OR	WA	Total
Office - Med & Large	0.06	0.02	0.11	0.47	0.34
Office – Small	0.09	0.34	0.22	0.55	0.33
Retail - BB/Anchor	0.18	0.34	0.18	0.50	0.36
Retail - Small/HE	0.09	0.11	0.23	0.57	0.36
K–12	0.10	0.58	0.33	0.55	0.40
University	0.15	0.50	0.40	0.48	0.42
Warehouse	0.17	0.30	0.11	0.49	0.34
Grocery	0.24	0.75	0.26	0.56	0.45
Restaurant	0.10	0.21	0.14	0.51	0.30
Lodging	0.02	0.37	0.24	0.54	0.39
Hospital	0.14	0.26	0.52	0.64	0.53
Other Health	0.10	0.24	0.20	0.66	0.45
Assembly	0.17	0.30	0.27	0.45	0.35
Other	0.11	0.20	0.27	0.56	0.41
Total	0.12	0.33	0.23	0.53	0.38

Table A2 presents the fraction of 2002–2007 nonresidential new construction (total 11,894 projects) floor area in a given state and building type served by Preference Rural utilities.

Table A2. Fraction of Forecast Floor Area Served by Rural Preference Utilities (Fraction of State/Building Type Forecast Floor Area)

Building Type	ID	MT	OR	WA	Total
Office - Med & Large	0.06	0.02	0.04	0.02	0.03
Office – Small	0.08	0.06	0.07	0.06	0.07
Retail - BB/Anchor	0.09	0.01	0.06	0.05	0.06
Retail - Small/HE	0.07	0.04	0.07	0.04	0.06
K–12	0.09	0.10	0.18	0.05	0.09
University	0.14	0.33	0.06	0.08	0.09
Warehouse	0.13	0.07	0.04	0.08	0.07
Grocery	0.24	0.03	0.06	0.08	0.10
Restaurant	0.06	0.03	0.04	0.03	0.04
Lodging	0.02	0.01	0.06	0.03	0.04
Hospital	0.10	0.11	0.04	0.06	0.06
Other Health	0.09	0.07	0.04	0.04	0.05
Assembly	0.15	0.10	0.11	0.04	0.08
Other	0.11	0.06	0.09	0.14	0.12
Total	0.10	0.07	0.07	0.06	0.07

Table A3 presents the fraction of 2002–2007 nonresidential new construction (total 11,894 projects) floor area in a given state and building type served by Preference Program Involvement – Low utilities.

Table A3. Fraction of Forecast Served by Program Involvement - Low Utilities (Fraction of State/Building Type Forecast Floor Area)

Building Type	ID	MT	OR	WA	Total
Office - Med & Large	0.00	0.00	0.03	0.01	0.01
Office – Small	0.02	0.28	0.08	0.08	0.07
Retail - BB/Anchor	0.09	0.33	0.09	0.10	0.11
Retail - Small/HE	0.02	0.08	0.08	0.09	0.07
K–12	0.01	0.48	0.11	0.12	0.10
University	0.01	0.17	0.20	0.12	0.13
Warehouse	0.04	0.24	0.02	0.09	0.07
Grocery	0.00	0.72	0.15	0.08	0.10
Restaurant	0.04	0.18	0.05	0.10	0.08
Lodging	0.00	0.36	0.11	0.13	0.11
Hospital	0.04	0.16	0.11	0.06	0.08
Other Health	0.01	0.17	0.05	0.08	0.07
Assembly	0.02	0.20	0.11	0.08	0.08
Other	0.00	0.14	0.09	0.05	0.06
Total	0.02	0.26	0.08	0.08	0.08

Table A4 presents the Fraction of 2002–2007 nonresidential new construction (total 11,894 projects) floor area in a given state and building type served by Preference Program Involvement - High utilities.

Table A4. Fraction of Forecast Served by Program Involvement - High Utilities (Fraction of State/Building Type Forecast Floor Area)

Building Type	ID	MT	OR	WA	Total
Office - Med & Large	0.00	0.00	0.05	0.43	0.29
Office - Small	0.00	0.00	0.06	0.42	0.20
Retail - BB/Anchor	0.00	0.00	0.03	0.36	0.20
Retail - Small/HE	0.00	0.00	0.08	0.43	0.23
K–12	0.00	0.00	0.05	0.38	0.21
University	0.00	0.00	0.13	0.28	0.19
Warehouse	0.00	0.00	0.04	0.32	0.20
Grocery	0.00	0.00	0.06	0.40	0.25
Restaurant	0.00	0.00	0.05	0.38	0.18
Lodging	0.00	0.00	0.07	0.38	0.24
Hospital	0.00	0.00	0.36	0.53	0.39
Other Health	0.00	0.00	0.11	0.54	0.33
Assembly	0.00	0.00	0.05	0.33	0.19
Other	0.00	0.00	0.08	0.37	0.23
Total	0.00	0.00	0.08	0.39	0.23

Attachment B. Utility Assignment Method Development

The assignment of electric utility based upon a building's address is useful in analyzing regional project and audit data. The ideal method would be to geocode addresses and compare the result with utility boundary maps. The geocoding process is relatively easy. Unfortunately, utility boundary information is not currently available. Therefore, after some further development to better account for commercial areas and addresses without zip codes, a utility mapping based upon zip code and county, developed as part of the RBSA project, was used.

Using zip codes to assign utility has several problems:

- Zip codes in general are constantly changing based upon the needs of the postal delivery system. New zip codes are created, old ones deleted, and addresses moved from one to the other.
- Utility boundaries do not correspond to zip code boundaries. For many locations, utilities serve large areas and a majority of zip codes are served by a single utility, but for others, two or more utilities serve the same area. Based upon the initial mapping, 17% of new nonresidential floor area occurs in zip codes having more than one utility.
- Available address information may not be the building address, but rather the developer's or owner's address. The quality of the address list must be accounted for.

The basic utility assignment map developed as part of the RBSA is based upon census zip code tabulation areas (CZTAs). The RBSA contractor and the BPA provided this mapping.

The RBSA mapping lists each utility serving a CZTA with its relative importance. The relative importance is based upon a model proportioning census residential building estimates to areas based upon map information, with the constraint that the CZTA assignment model's prediction of total residential customers for a utility must agree with utility residential customer counts. For nonresidential estimates this residential weighting is problematic. There is reason to believe the weights do not apply well to commercial construction, which tends to be a population that utilities target. This work did not attempt to develop separate nonresidential weights. Therefore the weights are both very approximate and not representative of nonresidential buildings. It should be noted that only 17% of regional new construction floor area occurs in CZTAs that are indicated as being served by more than one utility.

For multiple utility zip codes, only the probability of the utility provider is known. This is fine for population estimates but will be of limited worth if used for trying to positively identify utilities at a project site. Since the current work is developing population estimates, the probabilities are used to apportion project floor area to each utility serving the zip code area.

Matching CZTAs with address information has many limitations with respect to electric utility assignment. Foremost is that the CZTA is not a U.S. Postal Service zip code area. Rather, it is a group of census blocks that can contain many whole or partial zip codes, of which the dominant residential zip code is assigned to identify the CZTA. Some USPS zip codes do not appear as CZTA codes and are instead wholly contained within one or more

CZTAs. In this case, assuming that the CZTA is the same as a postal zip code will lead to an unmatched zip code, and also to errors in surrounding zip codes that are matched to CZTAs. There is no "crosswalk" between CZTA and USPS zip codes.

Comparing the supplied mapping with a list of current USPS zip codes showed that 24% of Pacific Northwest region zip codes existing in 2010 were not present in the mapping. The USPS categorizes zip codes. The unmatched zip codes had a somewhat higher proportion of "post office box only" zip codes and contained nearly all of the "unique" zip codes representing large facilities and mailing centers (e.g., Fort Lewis, the University of Washington, Qwest Communications [now CenturyLink], Capital One Financial Corp.). To the extent that these are mailing centers, it is unclear whether building addresses would be associated with them. However, some of the unique zip codes clearly do have buildings associated with them. The post office box addresses are hard to understand. The data set being matched is supposed to have site addresses, and auditing experience bears this out, but clearly many have zip codes classified as "post office box only". The "post office box only" zip codes were assigned to the utility serving the general area.

Since commercial buildings tend to be located together, the zip code mapping file was merged with a list from RW Dodge of 13,383 new construction projects started between 2002 and 2007. Of these, 21% of the projects, representing 9% of the floor area, did not match. Many of the unmatched projects did not have zip codes. Of the sites having zip codes, 93.5% were matched. The unmatched zip codes were reviewed and, where possible, utility assignment data was developed for the zip code in question. In many cases zip codes assigned to single entities (e.g., universities) were not present in the CZTA data but were easily assigned to a specific utility. This assignment was done conservatively. That is, cases in which the zip code could be assigned to two or more utilities were left without assignment. The resulting file is referred to as the CZTA+ match file.

Due to the large number of projects missing zip code data, two additional data sets were developed. The first, a partial list of utilities by city, was developed on an as-needed basis. This partial city list contains data for only the limited number of cities that did not match with the 2002-2007 RW Dodge data set. Also, it only includes cities where a single utility is expected. Data was assigned based upon the BPA utility map. For Idaho a list of utilities by city, developed by the PUC was used.

A second data set, a complete list of utilities by county, was also developed; it contains probabilities for each utility serving a county. This file was developed from the CZTA+ file by summarizing all utilities in the county and assigning weights based upon the CZTA+ weights. Some counties are served by a single utility, and this therefore results in a perfect list, whereas other counties have so many utilities that this is a poor substitute for the zip code match. (Pierce County, WA, for example, is served by fifteen utilities.)

To assign utilities, a three-tier process is proposed. First, project zip codes are matched to the CZTA+ assignment file. Next, projects without zip codes and those that did not match the CZTA+ utility assignment file are matched with the city file that assigns a utility based upon city. Lastly, for projects without a zip or city utility assignment, an assignment based upon county is made.

Match Improvement

The initial mapping with the BPA-provided CZTA mapping matched 79% of the projects (91% of floor area). Some projects were found to have no location data: no zip code, city, or county information (8.7% of projects / 2.7% of floor area). These were removed. For the remaining projects the CZTA file matched 85% of the projects (93% of floor area). This group had zip codes for 91% of the projects, and the CZTA file matched zip codes for 93.5% of these projects. With the updated CZTA+ file, 87.6% of the projects (96% of floor area) are matched. The CZTA+ file matched 96.3% of the projects with zip codes. Of the remaining projects (12.4% of the total), 32% are matched by the city list, and the rest match by county.

Utility Zip Code Map Check

The utility assignment using the CZTA+ data to match USPS zip codes was tested using the CBSA data set. The CBSA data set is not randomly selected by utility, so the actual projected floor area by utility or utility customer type cannot be checked. It can be used to test whether the utility recorded in the CBSA data is among the possible utilities in the zip code map.

The CBSA data set contains 2026 data buildings with utility data. The CZTA+ database matches 98.6% (1998 buildings) of the CBSA zip codes. The CZTA+ utility assignment was compared with the CBSA assignment. In 95% of the matched cases, the CBSA utility was in the possible utilities predicted by the mapping method. Reviewing the sites where the CBSA utility was not predicted revealed a few issues. The CBSA reliance on specific utilities for some of the audits resulted in at least one rural county in which an IOU with a tiny presence (only a few percent of the land area) was the source for all CBSA audits in the county. The IOU was not listed as serving zip codes in that county, and so several mismatches resulted. If the to-be-matched data set were a random set of commercial customers, then the number of mismatches would be greatly reduced. So the overall error rate here is not as bad as it at first appears. From the BPA preference utility / other utility perspective, 63% of the mismatches are preference to preference, or other to other. The errors will therefore have a smaller impact on the BPA preference utility / other utility split.

Attachment C. CBSA Summaries by Customer Group

This attachment presents summaries from the CBSA database using the CBSA utility name to categorize floor area by customer group. Table C1 presents the fraction of total post-1994 CBSA floor area (744 total project) served by BPA preference utilities as estimated from the CBSA utility information. It can be compared with Table A1 to provide perspective on the regional differences between the CBSA and the RW Dodge data. The fraction of overall regional floor area served by preference utilities is similar between the two data sources. The fraction of floor area in each state is dramatically different, with relatively more Washington floor area and relatively less Idaho and Oregon floor area being served by preference utilities. Since there are known geographical issues with the CBSA data set, this difference is not surprising. This notwithstanding, the CBSA data set can provide useful information on energy use characteristics such as heating fuel saturation. Conclusions drawn from the CBSA data set must be carefully weighed, given the geographical differences.

Table C1. State and Building Type Served by Preference Utilities (Fraction of Each; Post-1994 CBSA Floor Area)

Building Type	ID	MT	OR	WA	Total
Office - Med & Large	0.00	1.00	0.09	0.72	0.38
Office - Small	0.06	0.00	0.41	0.52	0.35
Retail - BB/Anchor	0.00	0.81	0.11	0.46	0.30
Retail - Small/HE	0.09	0.89	0.23	0.77	0.55
K–12	0.08	0.26	0.24	0.64	0.43
University	0.00	0.00	0.38	0.93	0.46
Warehouse	0.00	0.00	0.06	0.49	0.29
Grocery	0.30	—	0.14	0.42	0.35
Restaurant	0.00	—	0.00	0.33	0.16
Lodging	0.42	0.50	0.00	0.47	0.25
Hospital	0.00	1.00	0.36	0.67	0.47
Other Health	0.00	0.00	0.12	0.64	0.38
Other	0.07	0.00	0.20	0.68	0.48
Total	0.05	0.23	0.15	0.60	0.38

A few basic summaries of post-1994 CBSA characteristics for preference utilities have been developed. These summaries are primarily useful for comparing preference utilities with other (non- preference) utilities. The preference utility types (rural, Program Involvement - Low, Program Involvement - High) are very poorly populated especially when looking at the building type distribution. Differences in building type distribution can significantly impact results. Therefore, preference utility type results should be treated as qualitative indicators rather than used for quantitative purposes.

Table C2 presents the distribution of floor area by primary heating fuel type. Preference utilities are indicated as having 5% higher saturation of electric heat and 12% lower gas heat saturation than other (non-preference) utilities. Looking at the preference utility types there are large variations in fuel saturations between groups, particularly with the saturation of electric heat. This is difficult to interpret due to the underlying sample size but it is clear the PIL utilities have significantly more electric heat than rural and PIH preference utilities.

Table C2. Floor Area Distribution by Primary Heating Fuel by Customer Group (% of CBSA Post-1994)

Primary Heating Fuel	Preference Utilities				Other utilities	Region
	All	Rural	PIL	PIH		
Electricity	22.71	17.65	36.88	21.13	17.56	19.60
Natural Gas	65.99	63.81	51.56	68.66	77.21	72.76
Fuel Oil	1.41	0.00	0.00	1.84	0.04	0.58
LPG	2.85	10.11	11.21	0.45	1.49	2.03
Pur. HW or Steam	3.98	0.00	0.35	5.14	0.40	1.82
Other	0.00	—	0.00	0.56	0.39	0.23
Geothermal	1.35	8.44	0.00	2.23	2.72	2.17
NOHEAT	1.71	0.00	100.00	21.13	0.20	0.80
Total	100.00	100.00	36.88	100.00	100.00	100.00

Table C3 presents the distribution of floor area by building size and customer group. Overall, preference utilities have the same size distribution as other utilities. Looking at preference utility types clear trends are apparent, with PIH utilities having relatively larger projects and rural and suburban utilities having relatively smaller projects. Small under 20000ft^2 buildings contain 44%, 40%, and 14% of the floor area served by rural, PIL, and PIH preference utilities respectively. Over 50000ft^2 buildings contain 47%, 37%, and 66% of the floor area served by rural, PIL, and PIH preference utilities, respectively.

Table C3. Floor Area Distribution by Building Size by Customer Group (% of CBSA Post-1994)

Building Size (ft^2)	Preference Utilities				Other utilities	Region
	All	Rural	PIL	PIH		
1. <5,000	4.27	12.45	3.67	3.20	4.63	4.49
2. 5,000–20,000	16.51	31.06	36.43	11.22	17.00	16.81
3. 20,000–50,000	18.55	9.91	22.52	19.13	20.47	19.72
4. 50,000–100,000	20.18	20.23	19.08	20.36	18.47	19.14
5. 100,000–500,000	39.25	26.35	18.31	44.47	35.04	36.69
6. >500,000	1.25	0.00	0.00	1.62	4.39	3.16
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table C4 presents the average CBSA lighting power density by customer group. Lighting power is very similar between the preference and other (non-preference) utilities. The standard deviation of the average lighting power for the region is presented for perspective and indicates a very large range of lighting power. Based upon this summary, there is no statistically significant difference between preference and other utility lighting power.

Table C4. Average Lighting Power Density by Building Type and Customer Group (CBSA Post-1994 W/ft^2)

Building Type	Preference utilities	Other utilities	Region	
			LPD (avg)	LPD (std. deviation)
Office – Large	0.99	1.03	1.02	0.30
Office – Small	1.01	1.22	1.14	0.28
Retail – Large	1.73	1.35	1.46	0.53
Retail – Small	1.36	1.41	1.38	0.63
School (K–12)	1.18	1.10	1.14	0.26
University	1.08	1.10	1.09	0.25
Warehouse	0.68	0.71	0.71	0.39
Grocery	1.45	1.68	1.60	0.40
Restaurant	1.68	1.15	1.24	0.42
Lodging	0.70	0.94	0.88	0.40
Hospital	1.21	1.15	1.18	0.25
Other Health	1.26	1.27	1.27	0.36
Other	1.07	1.06	1.07	0.36
Total	1.12	1.08	1.09	0.45

Attachment D. Northwest Electric Utility List

Utility Name	PTR Number	BES Number	Preference Utility	Pref. Rural	Pref. Urban
Albion, City of	16	10055	Yes	Yes	
Alder Mutual	40	10005	Yes	Yes	
Ashland, City of	100	10057	Yes		
Avista Corp	155	10016	No		
Bandon, City of	101	10059	Yes	Yes	
Benton County PUD #1	43	10024	Yes		
Benton REA	44	10025	Yes	Yes	
Big Bend Elec Coop	45	10027	Yes	Yes	
Blachly Lane Elec Coop	102	10029	Yes	Yes	
Blaine, City of	46	10061	Yes	Yes	
Bonners Ferry, City of	18	10062	Yes	Yes	
Burley, City of	19	10064	Yes		
Canby, City of	103	10044	Yes		
Cascade Locks, City of	104	10065	Yes	Yes	
Cashmere, City of	none	none	No		
Central Electric Coop	105	10046	Yes	Yes	
Central Lincoln PUD	106	10047	Yes		
Centralia, City of	47	10066	Yes		
Chelan County PUD #1	48	10050	No		
Cheney, City of	49	10067	Yes		
Chewelah, City of	50	10068	Yes	Yes	
Clallam County PUD #1	51	10101	Yes		
Clark County PUD #1	52	10103	Yes		Yes
Clatskanie PUD	107	10105	Yes		
Clearwater Power	20	10106	Yes	Yes	
Columbia Basin Elec Coop	108	10109	Yes	Yes	
Columbia Power Coop	109	10111	Yes	Yes	
Columbia REA	53	10113	Yes	Yes	
Columbia River PUD	110	10112	Yes		
Consumers Power	111	10118	Yes	Yes	
Coos Curry Elec Coop	112	10121	Yes		
Coulee Dam, City of	54	10378	Yes	Yes	
Cowlitz County PUD #1	55	10123	Yes		
Declo, City of	21	10070	Yes	Yes	
Douglas County PUD #1	56	10135	No		
Douglas Electric Cooperative	113	10136	Yes	Yes	
Drain, City of	114	10071	Yes	Yes	
East End Mutual Electric	22	10142	Yes	Yes	
Eatonville, City of	58	10144	Yes	Yes	
Ellensburg, City of	59	10072	Yes		
Elmhurst Mutual P & L	60	10156	Yes	Yes	

Utility Name	PTR Number	BES Number	Preference Utility	Pref. Rural	Pref. Urban
Emerald PUD	115	10157	Yes	Yes	
Eugene Water & Electric Board	116	10170	Yes		Yes
Fall River Elec Coop	23	10173	Yes	Yes	
Farmers Elec Coop	24	10174	Yes	Yes	
Federal			Yes	Yes	
Ferry County PUD #1	62	10177	Yes	Yes	
Flathead Elec Coop	9	10179	Yes		
Forest Grove, City of	117	10074	Yes		
Franklin County PUD #1	64	10183	Yes		
Glacier Elec Coop	10	10186	Yes	Yes	
Grant County PUD #2	65	10190	Yes	Yes	
Grays Harbor PUD #1	66	10191	Yes		
Harney Elec Coop	118	10197	Yes	Yes	
Hermiston, City of	168	10597	Yes		
Heyburn, City of	25	10076	Yes	Yes	
Hood River Elec Coop	119	10202	Yes		
Idaho County L & P	26	10203	Yes	Yes	
Idaho Falls Power	150	10205	Yes		
Idaho Power Co	150	10205	No		
Inland P & L	67	10209	Yes	Yes	
Kittitas County PUD #1	68	10230	Yes	Yes	
Klickitat County PUD #1	69	10231	Yes	Yes	
Kootenai Electric Coop	28	10234	Yes	Yes	
Lakeview L & P (WA)	70	10235	Yes		
Lane County Elec Coop	120	10236	Yes	Yes	
Lewis County PUD #1	71	10237	Yes	Yes	
Lincoln Elec Coop (MT)	11	10239	Yes	Yes	
Lost River Elec Coop	29	10242	Yes	Yes	
Lower Valley Energy	6	10244	Yes		
Mason County PUD #1	72	10246	Yes	Yes	
Mason County PUD #3	73	10247	Yes		
McCleary, City of	74	10078	Yes	Yes	
McMinnville, City of	121	10079	Yes		
Midstate Elec Coop	122	10256	Yes	Yes	
Milton, Town of	75	10080	Yes	Yes	
Milton-Freewater, City of	123	10081	Yes		
Minidoka, City of	30	10082	Yes	Yes	
Mission Valley	12	10258	Yes	Yes	
Missoula Elec Coop	13	10259	Yes	Yes	
Modern Elec Coop	76	10260	Yes		
Monmouth, City of	124	10083	Yes	Yes	
Nespelem Valley Elec Coop	77	10273	Yes	Yes	
Northern Lights	31	10278	Yes	Yes	

Utility Name	PTR Number	BES Number	Preference Utility	Pref. Rural	Pref. Urban
Northern Wasco County PUD	125	10279	Yes		
NorthWestern Corporation	176	10262	No		
Ohop Mutual Light Company	78	10284	Yes	Yes	
Okanogan County Elec Coop	79	10285	Yes	Yes	
Okanogan County PUD #1	80	10286	Yes		
Orcas P & L	81	10288	Yes	Yes	
Oregon Trail Coop	126	10291	Yes		
Pacific County PUD #2	82	10294	Yes		
PacifiCorp	157	10300	No		
Parkland L & W	83	10304	Yes		
Pend Oreille County PUD #1	84	10306	Yes		
Peninsula Light Company	85	10307	Yes	Yes	
Plummer, City of	32	10086	Yes	Yes	
Port Angeles, City of	86	10087	Yes		
Portland General Electric Co	156	10314	No		
Puget Sound Energy Inc	159	10325	No		
Raft River Elec Coop	33	10331	Yes	Yes	
Ravalli County Elec Coop	14	10333	Yes	Yes	
Richland, City of	88	10089	Yes		
Riverside Elec Coop	34	10338	Yes	Yes	
Rupert, City of	35	10091	Yes	Yes	
Ruston, Town of	none	none	No		
Salem Elec Coop	127	10342	Yes		
Salmon River Elec Coop	36	10343	Yes	Yes	
Seattle City Light	90	10349	Yes		Yes
Skamania County PUD #1	91	10352	Yes	Yes	
Snohomish County PUD #1	92	10354	Yes		Yes
Soda Springs, City of	37	10094	Yes	Yes	
Southside Elec Lines	191	10360	Yes	Yes	
Springfield Utility Board	128	10363	Yes		Yes
Steilacoom, Town of	93	10379	Yes	Yes	
Sumas, Town of	94	10095	Yes	Yes	
Surprise Valley Elec Coop	7	10369	Yes	Yes	
Tacoma Public Utilities	95	10370	Yes		Yes
Tanner Elec Coop	96	10371	Yes		
Tillamook PUD #1	129	10376	Yes		
Troy, City of	8	10097	Yes	Yes	
Umatilla Elec Coop	130	10388	Yes	Yes	
United Electric Coop	39	10391	Yes		
Vera Irrigation District	97	10434	Yes		
Vigilante Elec Coop	15	10436	Yes	Yes	
Wahkiakum County PUD #1	98	10440	Yes	Yes	
Wasco Elec Coop	131	10442	Yes	Yes	

Utility Name	PTR Number	BES Number	Preference Utility	Pref. Rural	Pref. Urban
Weiser, City of	189	11680	Yes	Yes	
Wells Rural Elec Coop	149	10446	Yes	Yes	
West Oregon Elec Coop	132	10448	Yes	Yes	
Yellowstone Valley Electric Coop			No		

The following utilities were not part of the summaries in this work.

Asotin County PUD #1	Water utility that buys power for their needs only
Consolidated Irrigation District #19	Water utility that buys power for their needs only
Energy Northwest	?
Jefferson County PUD #1*	Not taking delivery of power yet. Will start in 2013. Assign all zips in east Jefferson county (98368, 98320, 98376, 98365, 98339, 98325).
Port of Seattle – Sea-Tac Intl Airport	
Umpqua Indian Utility Cooperative	
US Air Force Base, Fairchild	
US DOE Albany Research Center	
US DOE Richland Operations Office	
US Naval Base, Bremerton	
US Naval Station, Everett (Jim Creek)	
US Naval Submarine Base, Bangor	
Whatcom County PUD #1	
Yakama Power	