Cost and Savings Analysis of the Proposed 2012 Washington State Energy Code

Submitted to the Washington State Building Code Council

by the

Northwest Energy Efficiency Alliance

based on work by:

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To support the Washington State Building Code Council (SBCC) in the development and adoption of the 2012 state energy code, the Northwest Energy Efficiency Alliance funded this analysis based on the proposed language posted by the SBCC as the "Annotated Commercial mash-up with TAG recommended proposals and modifications (As of June 22, 2012)"[1]. This document provides an estimate of the cost and energy savings resulting from changing from the 2009 Washington State Energy Code to the proposed language.

In 2009 the SBCC decided to transition the WSEC from a state-maintained code to the format of the IECC. This process required significant edits of the IECC to ensure that the new code achieved as much or more energy savings as the current code. It also required that the Energy Technical Advisory Group (TAG) consider the areas of the IECC 2012 where that code exceeded the provisions of the 2009 WSEC. The "mash-up" that resulted from this process was used as the base document for the code development process. It was then modified by code changes proposed to the SBCC as part of the regular code updating process.

Analysis Overview

The analysis method used in this report provides the incremental energy savings and cost estimates for going from the 2009 WSEC to the proposed 2012 code. It is designed to reflect the impacts of the application of a statewide code on future new construction as a whole. This method has been used by the Northwest Power and Conservation Council for more than 20 years to estimate regional energy savings potential from improvements to new and existing buildings.

The process is as follows:

- Estimate the difference between the base code (WSEC 2009) and the proposed code (WSEC 2012) for a sample of recently constructed buildings.
- Summarize the sample building traits, as estimated for the two codes, by building type and climate zone.
- Estimate energy savings for the code changes in fourteen representative prototype buildings using energy simulation software.
- Energy savings from the simulation of prototype buildings are combined with first cost data
- The result of each individual analysis is weighted based on the expected population growth for the specific scenario. This provides a weighted savings and cost for each building prototype and a weighted result for all commercial buildings.

The primary data used in this work is the inventory of 350 buildings collected for the "NEEA Baseline Characteristics of the 2002-2004 Nonresidential Sector" (Ecotope 2008)[2] study. The code is "applied" to each building in the inventory so that each building has customized code values for things such as lighting power density and code envelope u-values. These code values are averaged by building type to produce an average code trait for each building type and code. This trait is based upon substantial number of individual buildings for any given building type and is the average that results from the space type and component mixes found in the inventory. The code energy savings is then estimated by modeling the average base and proposed code characteristic for each building type.

[1] https://fortress.wa.gov/ga/apps/SBCC/File.ashx?cid=2259

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

The 14 prototypical building models used in this study were developed by PNNL to represent average building designs based on Commercial Buildings Energy Consumption Survey[3] (CBECS) data. Detailed descriptions of each prototype are included in the PNNL document referenced above. The prototypes used in this analysis included offices, groceries, retail, restaurants, warehouses, schools, and hospital/healthcare. Additional building types, such as assembly, churches, and smaller end uses are aggregated in the "other" category.

The NEEA Baseline data has also been used to adjust the prototype glazing areas to reflect average conditions. The analysis also incorporates the Northwest Power and Conservation Council new construction floor area forecast to determine the estimated new floor area by building type. Data from FW Dodge for six years of new northwest construction activity (2002–2007) is used to determine the geographic distribution of new construction within the state.

Evaluated Code Changes

The first step of this project was to identify all code changes and choose items for evaluation. The list of code provision changes were prioritized by anticipated magnitude of cost and energy savings. This study is limited to code changes that can be quantitatively evaluated. Table 1 presents the measures evaluated. A more detailed list of energy code differences is given in Appendix A.

Table 1. Evaluated Measures

Code Provisions	**Section**
Mandatory	
Envelope Changes (option 1) including reduction of maximum glazing allowance	402
2010 Equipment Efficiency EER Changes (Table)	403.2.3
Commissioning	408
Automatic Lighting Controls	405.2
LPD Changes	405.5
Minimum Skylight Area	402.3
Metering	409
New Fan Power Requirements	403.2
Additional Efficiency Options	
HVAC Equipment	406.2
Lighting Controls	406.3
Renewables (PV Assumed)	406.4
Envelope	406.5

[3] Energy Information Administration, 2003 Commercial Energy Consumption Survey, Building Characteristics http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html

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.

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, only the changes from 2009 WSEC zones 1 and 2 to the 2012 WSEC proposal zones 4c and 5b, respectively, are evaluated. One of the new proposed Washington zones (6b) has not been evaluated. This zone encompasses four small rural counties in Washington representing 0.8% of new nonresidential floor area.

Prototype Buildings and Simulations

Simulations were conducted using the eQUEST building energy simulation program and prototypical buildings developed for the Bonneville Power Administration (BPA). The eQUEST program was chosen to make use of its batch processing capabilities.

Table 2 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, with a few additional variations. For example, grocery and university were adopted from a regional study developed for BPA. Since the PNNL models were developed using the EnergyPlus building simulation software the descriptions were translated to eQUEST for the BPA project. 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 in the PNNL document referenced above. In particular, the score card spreadsheets are useful in providing detailed description for most prototypes,.

Table 2. Primary Prototype Descriptions Building Type

	Area (SF)	Baseline System/Fuel
Office - Large	498552	VAV - fanless terminals. Gas boiler, hot water reheat.
Office - Medium	53621	VAV - fanless terminals. Gas furnace, electric reheat.
Office - Small	5493	Split system single-zone heat pump, gas auxiliary
Retail_Strip_Mall	22500	Package single-zone, gas heat
Retail_Standalone	24696	Package single-zone, gas heat
Grocery	44998	Package single-zone, gas heat
School_Secondary	210955	VAV - fanless terminals. Gas boiler, hot water reheat. Package single-zone with gas furnace for some common areas.
School_Primary	73959	VAV - fanless terminals. Gas boiler, hot water reheat. Package single-zone with gas furnace for some common areas.
Warehouse	52050	Package single-zone, gas heat. Unit heaters.
Hospital	241500	VAV and CAV - fanless terminals. Gas boiler, hot water reheat.
Restaurant_Sitdown	5506	Package single-zone, gas heat
Restaurant_Fast_Food	2500	Package single-zone, gas heat
Hotel_Large	121700	Common areas: VAV; rooms: four pipe fan coils
Hotel_Small	42714	Common areas: package single-zone, gas heat; rooms: PTAC

The base model characteristics for window-to-wall ratio were updated based upon NEEA New Construction Survey data. The base model characteristics for LPD, envelope, and equipment efficiency for each prototype were updated to be consistent with the 2009 WSEC. Weighting between various space types, envelope components and equipment types was drawn from the NEEA New Construction Survey data.

Table 3 lists the climate zones used in modeling the various code increments. In all cases TMY2 weather data were used

Table 3. Weather Data

Code Climate Zone	Weather Station
2009 WSEC Zone 1 to 2012 Proposal Marine 4c	Seattle WA
2009 WSEC Zone 1 to 2012 Proposal 5b	Seattle WA
2009 WSEC Zone 2 to 2012 Proposal Marine 4c/5b	Spokane WA

Space heating fuel fractions for each prototype were assigned using the NEEA New Construction survey data. 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.

Cost Determination

Incremental cost estimates have been developed largely based upon the BPA Next Generation Codes evaluation and the costs developed for the Northwest Power and Conservation Council 6th Power Plan. The envelope costs, however, are based upon work by a cost estimator. This work was normalized to the square footage of each prototype.

Where new costs were 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.

Costs have not taken into account changes in HVAC system capacity that might be allowed or required from changes in lighting and envelope measures. Thus the benefit of the reduced system size and in some cases the opportunity for more efficient system design is not included in these costs. The result is that the costs shown are almost certainly higher than would be experienced by a builder optimizing the costs to meet the code. 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%.

For each of the code changes considered, the cost per square foot of floor area for each prototype in each climate zone is reported in Appendix C.

Cost and Savings Results

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

Energy savings from code provisions are estimated using building energy simulation supplemented with engineering calculations. Savings estimates are made on a floor-area basis for each building type. Total savings estimates combine the unit area savings estimate with the new construction/addition floor area forecasts from the Northwest Power and Conservation Council.

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 a direct code-to-code comparison, rather than evaluation of savings above standard practice. Table 4 summarizes the results of this analysis. The evaluation has been projected across the entire commercial building stock using the data sources explained above and an estimate of new commercial construction of about 27 million square feet per year across all building types. Energy costs used were $.077 per kWh for electricity and $1.01 per therm for gas.

Table 4: Savings Estimates by Code Section

Washington Energy Savings: 2009 WSEC to IECC 2012				
Cost and Savings by Code Section				
	Electric Savings	**Gas Savings**	**Energy**	**First Cost**
Code Section	**(kWh/sf)**	**(Therms/sf)**	**Savings ($)**	**($/SF)**
Envelope	0.1855	0.0066	$ 0.0209	$ 0.5117
HVAC	0.0692	-	$ 0.0053	$ 0.0184
HVAC Equipment	0.0016	-	$ 0.0001	$ -
Lighting	0.1999	(0.0015)	$ 0.0139	$ 0.0112
Lighting Control	-	-	$ -	$ 0.0009
Metering	0.3538	0.0039	$ 0.0312	$ 0.4248
Commissioning	0.1131	0.0059	$ 0.0147	$ 0.0863
Mandatory Total	**0.9231**	**0.0149**	**$ 0.0862**	**$ 1.0532**
		-	$ -	
Chapter 406, Pick One Option				
C406.2 HVAC	0.0603	0.0133	$ 0.0181	$ 0.5994
C406.3 Lighting Controls	0.7639	(0.0057)	$ 0.0531	$ 1.7405
C406.4 Renewables	0.2580	-	$ 0.0199	$ 1.2587
C406.5 Envelope	0.0574	0.0049	$ 0.0094	$ 0.1814
Sum of Mandatory plus each 406 option				
C406.2 HVAC	0.983	0.028	$ 0.1043	$ 1.6526
C406.3 Lighting Controls	1.687	0.009	$ 0.1393	$ 2.7938
C406.4 Renewables	1.181	0.015	$ 0.1060	$ 2.3119
C406.5 Envelope	0.981	0.020	$ 0.0955	$ 1.2346

Additional detail on these results are presented in the appendix.

Appendix A: Statewide Cost and Savings provides similar results to Table 4 by building type. This table estimates all cost and all savings on a statewide basis for the expected 27 million square feet of commercial building construction. In addition, for the state total, the cost benefit and internal rate of return is provided.

Appendix B: Cost and Savings Per Square Foot, By Building Type and Climate Zone, provide cost and savings per square foot by building type. This table examines the savings and cost per square foot impact on specific building types.

Appendix C: First Cost Per Square Foot of Floor Area provides the input data for cost applied to the models. It will be noted there are numerous cells that provide no cost. For example, 2010 Efficiency EER is blank because the upgrades in this category are in response to federal standards and essentially adopt in code the new standard practice. For others, such as Minimum skylight area, cells are left blank when the code change does not apply to a specific building type.

Appendix D: Measure Evaluation Details has been adopted from an earlier document, Next Generation Energy Code Analysis produced for BPA. This document details the measure analysis.

Appendix E: Financials, provides standard conditions used in calculating energy cost and life cycle cost. These were adopted from the recommendations made to the State Building Code Council by the Washington State Department of Commerce.

Appendix A: Statewide Cost and Savings

This appendix provides five tables that document statewide energy savings and first cost by building type. The first table provides cost and savings based on the mandatory sections. The following tables provide cost and savings for the mandatory measures plus each of the optional measures. Financial analysis is completed on the overall total using standard financial conditions noted in APPENDIX D.

Washington Energy Savings: 2009 WSEC to IECC 2012, Whole State, Commercial Customers

All Sections Except Section 406

Building Type	mWh	Gas mmBtu	First Year Savings($) (1000000s)	Total Cost ($) (1000000s)
Large Off	1,925	1,369	$ 0.16	$ 4.31
Medium Off	1,252	1,543	$ 0.11	$ 1.95
Small Off	575	755	$ 0.05	$ 0.42
Big Box-Retail	929	819	$ 0.08	$ 1.06
Small Box-Retail	1,263	3,893	$ 0.14	$ 0.75
High End-Retail	316	973	$ 0.03	$ 0.19
Anchor-Retail	828	730	$ 0.07	$ 0.94
K-12	2,264	5,020	$ 0.23	$ 1.78
University	1,284	2,983	$ 0.13	$ 1.07
Warehouse	4,865	3,777	$ 0.41	$ 10.13
Supermarket	264	447	$ 0.02	$ 0.23
Minimart	233	395	$ 0.02	$ 0.20
Restaurant	1,095	2,887	$ 0.11	$ 0.15
Lodging	1,314	3,322	$ 0.13	$ 0.34
Hospital	1,273	2,440	$ 0.12	$ 0.58
OtherHealth	3,177	5,601	$ 0.30	$ 2.09
Assembly	1,242	2,048	$ 0.12	$ 1.36
Other	759	1,252	$ 0.07	$ 0.83
Total	24,858	40,255	$ 2.32	$ 28.36
Simple Payback				12.2
Savings to Investement Ratio				1.61
Adjusted Internal Rate of Return				10%

Washington Energy Savings: 2009 WSEC to IECC 2012, Whole State, Commercial Customers

Using Section 406.2 HVAC

Building Type	mWh	Gas mmBtu	First Year Savings($) (1000000s)	Total Cost ($) (1000000s)
Large Off	2,124	2,034	$ 0.18	$ 6.06
Medium Off	1,337	1,988	$ 0.12	$ 2.72
Small Off	646	1,293	$ 0.06	$ 2.51
Big Box-Retail	970	1,765	$ 0.09	$ 1.80
Small Box-Retail	1,394	6,009	$ 0.17	$ 2.31
High End-Retail	348	1,502	$ 0.04	$ 0.58
Anchor-Retail	865	1,574	$ 0.08	$ 1.61
K-12	2,433	7,807	$ 0.27	$ 2.93
University	1,371	4,101	$ 0.15	$ 1.79
Warehouse	4,882	10,267	$ 0.48	$ 12.35
Supermarket	273	1,184	$ 0.03	$ 0.46
Minimart	241	1,045	$ 0.03	$ 0.40
Restaurant	1,172	8,695	$ 0.18	$ 0.56
Lodging	1,411	3,900	$ 0.15	$ 0.73
Hospital	1,399	5,299	$ 0.16	$ 0.73
OtherHealth	3,480	11,462	$ 0.38	$ 3.45
Assembly	1,325	3,887	$ 0.14	$ 2.18
Other	810	2,375	$ 0.09	$ 1.33
Total	26,482	76,189	$ 2.81	$ 44.50
Simple Payback				15.8
Savings to Investement Ratio				1.26
Adjusted Internal Rate of Return				8.7%

Washington Energy Savings: 2009 WSEC to IECC 2012, Whole State, Commercial Customers

Use 406.3 Lighting Controls

Building Type	mWh	Gas mmBtu	First Year Savings($) (1000000s)	Total Cost ($) (1000000s)
Large Off	3,804	727	$ 0.30	$ 10.38
Medium Off	2,075	1,280	$ 0.17	$ 4.61
Small Off	2,062	38	$ 0.16	$ 3.56
Big Box-Retail	929	819	$ 0.08	$ 1.06
Small Box-Retail	1,263	3,893	$ 0.14	$ 0.75
High End-Retail	316	973	$ 0.03	$ 0.19
Anchor-Retail	828	730	$ 0.07	$ 0.94
K-12	4,771	2,922	$ 0.40	$ 6.13
University	2,413	2,037	$ 0.21	$ 3.43
Warehouse	10,595	1,125	$ 0.83	$ 27.94
Supermarket	264	447	$ 0.02	$ 0.23
Minimart	233	395	$ 0.02	$ 0.20
Restaurant	1,095	2,887	$ 0.11	$ 0.15
Lodging	1,879	2,979	$ 0.17	$ 1.41
Hospital	2,622	370	$ 0.21	$ 1.75
OtherHealth	6,645	1,266	$ 0.52	$ 6.59
Assembly	2,257	1,288	$ 0.19	$ 3.67
Other	1,379	787	$ 0.11	$ 2.24
Total	45,427	24,962	$ 3.75	$ 75.23
Simple Payback				20.1
Savings to Investement Ratio				0.96
Adjusted Internal Rate of Return				7.8%

Washington Energy Savings: 2009 WSEC to IECC 2012, Whole State, Commercial Customers

Using Section 406.4 Renewables

Building Type	mWh	Gas mmBtu	First Year Savings($) (1000000s)	Total Cost ($) (1000000s)
Large Off	2,402	1,369	$ 0.20	$ 6.52
Medium Off	1,480	1,543	$ 0.13	$ 3.01
Small Off	881	755	$ 0.08	$ 2.13
Big Box-Retail	1,164	819	$ 0.10	$ 2.15
Small Box-Retail	1,763	3,893	$ 0.18	$ 3.39
High End-Retail	441	973	$ 0.04	$ 0.85
Anchor-Retail	1,038	730	$ 0.09	$ 1.91
K-12	2,981	5,020	$ 0.28	$ 5.17
University	1,627	2,983	$ 0.16	$ 2.71
Warehouse	6,005	3,777	$ 0.50	$ 15.82
Supermarket	364	447	$ 0.03	$ 0.70
Minimart	322	395	$ 0.03	$ 0.61
Restaurant	1,336	2,887	$ 0.13	$ 1.60
Lodging	1,578	3,322	$ 0.16	$ 1.57
Hospital	1,684	2,440	$ 0.15	$ 2.44
OtherHealth	4,172	5,601	$ 0.38	$ 6.72
Assembly	1,593	2,048	$ 0.14	$ 3.07
Other	973	1,252	$ 0.09	$ 1.88
Total	31,805	40,255	$ 2.86	$ 62.25
Simple Payback				21.8
Savings to Investement Ratio				0.9
Adjusted Internal Rate of Return				7.5%

Washington Energy Savings: 2009 WSEC to IECC 2012, Whole State, Commercial Customers

Using Section 406.5 Envelope

Building Type	mWh	Gas mmBtu	First Year Savings($) (1000000s)	Total Cost ($) (1000000s)
Large Off	2,170	1,920	$ 0.19	$ 5.43
Medium Off	1,421	1,902	$ 0.13	$ 2.44
Small Off	723	1,389	$ 0.07	$ 0.72
Big Box-Retail	1,000	1,448	$ 0.09	$ 1.24
Small Box-Retail	1,474	5,367	$ 0.17	$ 0.84
High End-Retail	369	1,342	$ 0.04	$ 0.21
Anchor-Retail	892	1,291	$ 0.08	$ 1.10
K-12	2,464	7,163	$ 0.26	$ 2.04
University	1,325	3,811	$ 0.14	$ 1.29
Warehouse	4,907	4,982	$ 0.43	$ 10.86
Supermarket	266	580	$ 0.03	$ 0.25
Minimart	235	512	$ 0.02	$ 0.22
Restaurant	1,110	3,479	$ 0.12	$ 0.22
Lodging	1,230	3,581	$ 0.13	$ 0.38
Hospital	1,309	3,057	$ 0.13	$ 0.73
OtherHealth	3,370	7,160	$ 0.33	$ 2.69
Assembly	1,327	2,749	$ 0.13	$ 1.60
Other	811	1,680	$ 0.08	$ 0.98
Total	26,404	53,412	$ 2.57	$ 33.25
Simple Payback				12.9
Savings to Investement Ratio				1.53
Adjusted Internal Rate of Return				9.4%

Appendix B: Cost and Savings Per Square Foot, By Building Type and Climate Zone

The following fifteen tables provide cost and savings per square foot. For each climate zone there are four tables. The first is a code upgrade without any of the section 406 options. The four following tables provide the cost and savings when the specific 406 option is applied. There are three variations of climate zones analyzed. This includes changing from WSEC climate zone 1 to IECC climate zone 4c, WSEC climate zone 1 to IECC climate zone 5b, and WSEC climate zone 2 to IECC 5b.

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c							
Excluding 406	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.627	0.0044	$ 0.053	$1.42		7.2%	6.8%
Medium Off	0.932	0.0114	$ 0.083	$1.46		10.9%	9.9%
Small Off	0.360	0.0046	$ 0.032	$0.29		4.7%	4.2%
Big Box-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
Small Box-Retail	1.114	0.0335	$ 0.120	$0.68		10.9%	9.6%
High End-Retail	1.114	0.0335	$ 0.120	$0.68		10.9%	9.6%
Anchor-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
K-12	1.033	0.0231	$ 0.103	$0.83		10.0%	9.1%
University	1.076	0.0249	$ 0.108	$0.91		12.1%	10.9%
Warehouse	0.545	0.0041	$ 0.046	$1.14		11.3%	12.1%
Supermarket	1.662	0.0284	$ 0.157	$1.44		5.2%	5.0%
Minimart	1.662	0.0284	$ 0.157	$1.44		5.2%	5.0%
Restaurant	3.145	0.0812	$ 0.324	$0.44		4.2%	3.9%
Lodging	2.436	0.0613	$ 0.249	$0.64		17.3%	15.4%
Hospital	2.158	0.0414	$ 0.208	$0.99		6.8%	6.6%
OtherHealth	1.402	0.0247	$ 0.133	$0.93		7.0%	6.7%
Assembly	0.908	0.0143	$ 0.084	$1.06		8.6%	8.2%
Other	0.908	0.0143	$ 0.084	$1.06		8.6%	8.2%
Total	0.913	0.014	$ 0.085	$1.07		8.6%	8.2%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c							
w/406.2 HVAC	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.692	0.0065	$ 0.060	$2.00		8.5%	7.7%
Medium Off	0.995	0.0147	$ 0.091	$2.05		12.3%	10.9%
Small Off	0.403	0.0077	$ 0.039	$1.62		6.0%	5.1%
Big Box-Retail	1.590	0.0286	$ 0.151	$2.99		14.5%	13.7%
Small Box-Retail	1.225	0.0509	$ 0.146	$2.07		14.1%	11.8%
High End-Retail	1.225	0.0509	$ 0.146	$2.07		14.1%	11.8%
Anchor-Retail	1.590	0.0286	$ 0.151	$2.99		14.5%	13.7%
K-12	1.108	0.0354	$ 0.121	$1.35		12.6%	10.8%
University	1.147	0.0340	$ 0.123	$1.52		14.4%	12.4%
Warehouse	0.547	0.0113	$ 0.054	$1.39		14.9%	14.2%
Supermarket	1.717	0.0740	$ 0.207	$2.88		8.1%	6.7%
Minimart	1.717	0.0740	$ 0.207	$2.88		8.1%	6.7%
Restaurant	3.347	0.2420	$ 0.502	$1.63		7.9%	6.1%
Lodging	2.614	0.0715	$ 0.273	$1.37		19.3%	16.9%
Hospital	2.374	0.0896	$ 0.273	$1.24		10.1%	8.8%
OtherHealth	1.536	0.0504	$ 0.169	$1.53		10.0%	8.7%
Assembly	0.966	0.0269	$ 0.102	$1.65		11.4%	10.0%
Other	0.966	0.0269	$ 0.102	$1.65		11.4%	10.0%
Total	0.972	0.027	$ 0.102	$1.67		11.4%	10.0%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c							
w/C406.3 Lighting Control	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	1.248	0.0023	$ 0.098	$3.42		12.6%	12.6%
Medium Off	1.550	0.0095	$ 0.129	$3.46		15.8%	15.2%
Small Off	1.313	0.0003	$ 0.101	$2.29		12.6%	13.0%
Big Box-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
Small Box-Retail	1.114	0.0335	$ 0.120	$0.68		10.9%	9.6%
High End-Retail	1.114	0.0335	$ 0.120	$0.68		10.9%	9.6%
Anchor-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
K-12	2.184	0.0137	$ 0.182	$2.83		15.1%	15.9%
University	2.031	0.0171	$ 0.174	$2.91		17.0%	17.3%
Warehouse	1.188	0.0011	$ 0.093	$3.14		20.7%	24.1%
Supermarket	1.662	0.0284	$ 0.157	$1.44		5.2%	5.0%
Minimart	1.662	0.0284	$ 0.157	$1.44		5.2%	5.0%
Restaurant	3.145	0.0812	$ 0.324	$0.44		4.2%	3.9%
Lodging	3.496	0.0551	$ 0.325	$2.64		20.9%	19.9%
Hospital	4.450	0.0062	$ 0.349	$2.99		9.4%	11.0%
OtherHealth	2.941	0.0055	$ 0.232	$2.93		10.3%	11.6%
Assembly	1.667	0.0088	$ 0.137	$2.80		12.5%	13.2%
Other	1.667	0.0088	$ 0.137	$2.80		12.5%	13.2%
Total	1.678	0.009	$ 0.138	$2.82		12.5%	13.2%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c							
w/C406.4 Renewable	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.783	0.0044	$ 0.065	$2.14		8.7%	8.3%
Medium Off	1.101	0.0114	$ 0.096	$2.25		12.4%	11.4%
Small Off	0.550	0.0046	$ 0.047	$1.34		6.5%	6.1%
Big Box-Retail	1.900	0.0140	$ 0.160	$3.51		13.8%	14.4%
Small Box-Retail	1.546	0.0335	$ 0.153	$2.96		13.1%	12.2%
High End-Retail	1.546	0.0335	$ 0.153	$2.96		13.1%	12.2%
Anchor-Retail	1.900	0.0140	$ 0.160	$3.51		13.8%	14.4%
K-12	1.354	0.0231	$ 0.128	$2.35		11.9%	11.2%
University	1.360	0.0249	$ 0.130	$2.27		14.0%	13.1%
Warehouse	0.673	0.0041	$ 0.056	$1.77		13.4%	14.7%
Supermarket	2.284	0.0284	$ 0.205	$4.36		6.5%	6.5%
Minimart	2.284	0.0284	$ 0.205	$4.36		6.5%	6.5%
Restaurant	3.846	0.0812	$ 0.378	$4.67		4.7%	4.5%
Lodging	2.921	0.0613	$ 0.287	$2.92		19.3%	17.7%
Hospital	2.859	0.0414	$ 0.262	$4.16		8.3%	8.3%
OtherHealth	1.842	0.0247	$ 0.167	$2.98		8.5%	8.4%
Assembly	1.158	0.0143	$ 0.104	$2.27		10.2%	10.1%
Other	1.158	0.0143	$ 0.104	$2.27		10.2%	10.1%
Total	1.165	0.014	$ 0.104	$2.30		10.2%	10.1%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c

w/406.5 Envelope	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.706	0.0062	$ 0.061	$1.79		8.5%	7.8%
Medium Off	1.054	0.0140	$ 0.095	$1.83		12.6%	11.3%
Small Off	0.439	0.0082	$ 0.042	$0.50		6.4%	5.5%
Big Box-Retail	1.635	0.0239	$ 0.150	$2.06		13.9%	13.6%
Small Box-Retail	1.288	0.0454	$ 0.145	$0.77		13.6%	11.7%
High End-Retail	1.288	0.0454	$ 0.145	$0.77		13.6%	11.7%
Anchor-Retail	1.635	0.0239	$ 0.150	$2.06		13.9%	13.6%
K-12	1.119	0.0325	$ 0.119	$0.95		12.1%	10.6%
University	1.096	0.0314	$ 0.116	$1.10		13.6%	11.8%
Warehouse	0.550	0.0053	$ 0.048	$1.22		11.9%	12.5%
Supermarket	1.674	0.0364	$ 0.166	$1.61		5.7%	5.3%
Minimart	1.674	0.0364	$ 0.166	$1.61		5.7%	5.3%
Restaurant	3.183	0.0976	$ 0.344	$0.67		4.6%	4.1%
Lodging	2.229	0.0658	$ 0.238	$0.74		17.0%	14.7%
Hospital	2.217	0.0516	$ 0.223	$1.24		7.6%	7.1%
OtherHealth	1.482	0.0314	$ 0.146	$1.20		8.0%	7.4%
Assembly	0.960	0.0188	$ 0.093	$1.24		9.8%	9.1%
Other	0.960	0.0188	$ 0.093	$1.24		9.8%	9.1%
Total	0.965	0.019	$ 0.093	$1.26		9.8%	9.1%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b

Excluding 406	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.627	0.0044	$ 0.053	$1.42		7.2%	6.8%
Medium Off	0.932	0.0114	$ 0.083	$1.46		10.9%	9.9%
Small Off	0.360	0.0046	$ 0.032	$0.29		4.7%	4.2%
Big Box-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
Small Box-Retail	1.113	0.0335	$ 0.120	$0.68		10.9%	9.6%
High End-Retail	1.113	0.0335	$ 0.120	$0.68		10.9%	9.6%
Anchor-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
K-12	1.033	0.0231	$ 0.103	$0.83		10.0%	9.1%
University	1.076	0.0249	$ 0.108	$0.91		12.1%	10.9%
Warehouse	0.545	0.0041	$ 0.046	$1.14		11.3%	12.1%
Supermarket	1.652	0.0287	$ 0.156	$1.44		5.2%	5.0%
Minimart	1.652	0.0287	$ 0.156	$1.44		5.2%	5.0%
Restaurant	3.145	0.0812	$ 0.324	$0.44		4.2%	3.9%
Lodging	2.436	0.0613	$ 0.249	$0.64		17.3%	15.4%
Hospital	2.158	0.0414	$ 0.208	$0.99		6.8%	6.6%
OtherHealth	1.402	0.0247	$ 0.133	$0.93		7.0%	6.7%
Assembly	0.845	0.0133	$ 0.079	$1.00		9.0%	8.7%
Other	0.845	0.0133	$ 0.079	$1.00		9.0%	8.7%
Total	0.854	0.013	$ 0.079	$1.03		9.0%	8.7%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b							
Total Energy Savings							
w/406.2 HVAC	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.692	0.0065	$ 0.060	$2.00		8.5%	7.7%
Medium Off	0.995	0.0147	$ 0.091	$2.05		12.3%	10.9%
Small Off	0.403	0.0077	$ 0.039	$1.62		6.0%	5.1%
Big Box-Retail	1.590	0.0286	$ 0.151	$2.99		14.5%	13.7%
Small Box-Retail	1.223	0.0509	$ 0.146	$2.07		14.1%	11.7%
High End-Retail	1.223	0.0509	$ 0.146	$2.07		14.1%	11.7%
Anchor-Retail	1.590	0.0286	$ 0.151	$2.99		14.5%	13.7%
K-12	1.108	0.0354	$ 0.121	$1.35		12.6%	10.8%
University	1.147	0.0340	$ 0.123	$1.52		14.4%	12.4%
Warehouse	0.547	0.0113	$ 0.054	$1.39		14.9%	14.2%
Supermarket	1.706	0.0742	$ 0.206	$2.88		8.1%	6.7%
Minimart	1.706	0.0742	$ 0.206	$2.88		8.1%	6.7%
Restaurant	3.347	0.2420	$ 0.502	$1.63		7.9%	6.1%
Lodging	2.614	0.0715	$ 0.273	$1.37		19.3%	16.9%
Hospital	2.374	0.0896	$ 0.273	$1.24		10.1%	8.8%
OtherHealth	1.536	0.0504	$ 0.169	$1.53		10.0%	8.7%
Assembly	0.890	0.0257	$ 0.094	$1.55		11.9%	10.5%
Other	0.890	0.0257	$ 0.094	$1.55		11.9%	10.5%
Total	0.899	0.026		$1.57		11.9%	10.5%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b

w/406.3 Lighting Controls	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	1.248	0.0023	$ 0.098	$3.42		12.6%	12.6%
Medium Off	1.550	0.0095	$ 0.129	$3.46		15.8%	15.2%
Small Off	1.313	0.0003	$ 0.101	$2.29		12.6%	13.0%
Big Box-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
Small Box-Retail	1.113	0.0335	$ 0.120	$0.68		10.9%	9.6%
High End-Retail	1.113	0.0335	$ 0.120	$0.68		10.9%	9.6%
Anchor-Retail	1.524	0.0140	$ 0.131	$1.77		11.5%	11.8%
K-12	2.184	0.0137	$ 0.182	$2.83		15.1%	15.9%
University	2.031	0.0171	$ 0.174	$2.91		17.0%	17.3%
Warehouse	1.188	0.0011	$ 0.093	$3.14		20.7%	24.1%
Supermarket	1.652	0.0287	$ 0.156	$1.44		5.2%	5.0%
Minimart	1.652	0.0287	$ 0.156	$1.44		5.2%	5.0%
Restaurant	3.145	0.0812	$ 0.324	$0.44		4.2%	3.9%
Lodging	3.496	0.0551	$ 0.325	$2.64		20.9%	19.9%
Hospital	4.450	0.0062	$ 0.349	$2.99		9.4%	11.0%
OtherHealth	2.941	0.0055	$ 0.232	$2.93		10.3%	11.6%
Assembly	1.593	0.0081	$ 0.131	$2.76		13.3%	14.3%
Other	1.593	0.0081	$ 0.131	$2.76		13.3%	14.3%
Total	1.601	0.008	$ 0.131	$2.78		13.2%	14.3%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b

w/406.4 Renewables	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.783	0.0044	$ 0.065	$2.14		8.7%	8.3%
Medium Off	1.101	0.0114	$ 0.096	$2.25		12.4%	11.4%
Small Off	0.550	0.0046	$ 0.047	$1.34		6.5%	6.1%
Big Box-Retail	1.900	0.0140	$ 0.160	$3.51		13.8%	14.4%
Small Box-Retail	1.544	0.0335	$ 0.153	$2.96		13.1%	12.2%
High End-Retail	1.544	0.0335	$ 0.153	$2.96		13.1%	12.2%
Anchor-Retail	1.900	0.0140	$ 0.160	$3.51		13.8%	14.4%
K-12	1.354	0.0231	$ 0.128	$2.35		11.9%	11.2%
University	1.360	0.0249	$ 0.130	$2.27		14.0%	13.1%
Warehouse	0.673	0.0041	$ 0.056	$1.77		13.4%	14.7%
Supermarket	2.274	0.0287	$ 0.204	$4.36		6.5%	6.5%
Minimart	2.274	0.0287	$ 0.204	$4.36		6.5%	6.5%
Restaurant	3.846	0.0812	$ 0.378	$4.67		4.7%	4.5%
Lodging	2.921	0.0613	$ 0.287	$2.92		19.3%	17.7%
Hospital	2.859	0.0414	$ 0.262	$4.16		8.3%	8.3%
OtherHealth	1.842	0.0247	$ 0.167	$2.98		8.5%	8.4%
Assembly	1.082	0.0133	$ 0.097	$2.17		10.7%	10.6%
Other	1.082	0.0133	$ 0.097	$2.17		10.7%	10.6%
Total	1.091	0.013	$ 0.098	$2.19		10.7%	10.6%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b

w/406.5 Envelope	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.706	0.0062	$ 0.061	$1.79		8.5%	7.8%
Medium Off	1.054	0.0140	$ 0.095	$1.83		12.6%	11.3%
Small Off	0.439	0.0082	$ 0.042	$0.50		6.4%	5.5%
Big Box-Retail	1.635	0.0239	$ 0.150	$2.06		13.9%	13.6%
Small Box-Retail	1.286	0.0455	$ 0.145	$0.77		13.6%	11.7%
High End-Retail	1.286	0.0455	$ 0.145	$0.77		13.6%	11.7%
Anchor-Retail	1.635	0.0239	$ 0.150	$2.06		13.9%	13.6%
K-12	1.119	0.0325	$ 0.119	$0.95		12.1%	10.6%
University	1.096	0.0314	$ 0.116	$1.10		13.6%	11.8%
Warehouse	0.550	0.0053	$ 0.048	$1.22		11.9%	12.5%
Supermarket	1.663	0.0367	$ 0.165	$1.61		5.7%	5.3%
Minimart	1.663	0.0367	$ 0.165	$1.61		5.7%	5.3%
Restaurant	3.183	0.0976	$ 0.344	$0.67		4.6%	4.1%
Lodging	2.229	0.0658	$ 0.238	$0.74		17.0%	14.7%
Hospital	2.217	0.0516	$ 0.223	$1.24		7.6%	7.1%
OtherHealth	1.482	0.0314	$ 0.146	$1.20		8.0%	7.4%
Assembly	0.884	0.0176	$ 0.086	$1.14		10.1%	9.5%
Other	0.884	0.0176	$ 0.086	$1.14		10.1%	9.5%
Total	0.893	0.018	$ 0.087	$1.17		10.1%	9.5%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b

Excluding 406	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.737	0.0059	$ 0.063	$1.41		7.9%	7.4%
Medium Off	1.048	0.0135	$ 0.094	$1.45		11.3%	10.3%
Small Off	0.419	0.0062	$ 0.039	$0.14		4.9%	4.4%
Big Box-Retail	1.509	0.0089	$ 0.125	$1.44		9.1%	10.0%
Small Box-Retail	1.166	0.0421	$ 0.132	$0.54		10.4%	9.3%
High End-Retail	1.166	0.0421	$ 0.132	$0.54		10.4%	9.3%
Anchor-Retail	1.509	0.0089	$ 0.125	$1.44		9.1%	10.0%
K-12	1.098	0.0231	$ 0.108	$0.72		9.2%	8.7%
University	1.161	0.0273	$ 0.117	$0.82		11.7%	10.7%
Warehouse	0.561	0.0065	$ 0.050	$1.11		11.7%	12.4%
Supermarket	1.655	0.0259	$ 0.154	$1.28		4.9%	4.9%
Minimart	1.655	0.0259	$ 0.154	$1.28		4.9%	4.9%
Restaurant	3.417	0.1022	$ 0.366	$0.30		4.2%	3.9%
Lodging	2.577	0.0669	$ 0.266	$0.56		16.8%	15.1%
Hospital	2.249	0.0428	$ 0.216	$0.97		6.8%	6.7%
OtherHealth	1.491	0.0263	$ 0.141	$0.88		7.1%	6.8%
Assembly	1.072	0.0208	$ 0.104	$0.88		8.4%	8.1%
Other	1.072	0.0208	$ 0.104	$0.88		8.4%	8.1%
Total	1.073	0.020	$ 0.103	$0.91		8.4%	8.0%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b							
w/406.2 HVAC	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.812	0.0097	$ 0.072	$1.99		9.5%	8.6%
Medium Off	1.123	0.0180	$ 0.105	$2.03		12.9%	11.4%
Small Off	0.487	0.0122	$ 0.050	$1.47		6.8%	5.7%
Big Box-Retail	1.599	0.0316	$ 0.155	$2.70		13.0%	12.6%
Small Box-Retail	1.320	0.0702	$ 0.173	$1.94		14.6%	12.2%
High End-Retail	1.320	0.0702	$ 0.173	$1.94		14.6%	12.2%
Anchor-Retail	1.599	0.0316	$ 0.155	$2.70		13.0%	12.6%
K-12	1.193	0.0395	$ 0.132	$1.30		12.1%	10.7%
University	1.248	0.0396	$ 0.136	$1.47		14.3%	12.5%
Warehouse	0.564	0.0149	$ 0.058	$1.37		15.6%	14.7%
Supermarket	1.719	0.0777	$ 0.211	$2.75		8.2%	6.8%
Minimart	1.719	0.0777	$ 0.211	$2.75		8.2%	6.8%
Restaurant	3.789	0.3241	$ 0.619	$1.68		8.7%	6.7%
Lodging	2.779	0.0812	$ 0.296	$1.30		19.1%	16.9%
Hospital	2.459	0.0963	$ 0.287	$1.25		10.3%	9.0%
OtherHealth	1.632	0.0557	$ 0.182	$1.50		10.2%	8.9%
Assembly	1.157	0.0405	$ 0.130	$1.59		11.7%	10.2%
Other	1.157	0.0405	$ 0.130	$1.59		11.7%	10.2%
Total	1.158	0.040	$ 0.130	$1.61		11.7%	10.2%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b

w/406.3 Lighting Controls	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	1.332	0.0032	$ 0.106	$3.41		12.4%	12.5%
Medium Off	1.644	0.0110	$ 0.138	$3.45		15.4%	14.9%
Small Off	1.334	(0.0003)	$ 0.102	$2.14		10.7%	11.5%
Big Box-Retail	1.509	0.0089	$ 0.125	$1.44		9.1%	10.0%
Small Box-Retail	1.166	0.0421	$ 0.132	$0.54		10.4%	9.3%
High End-Retail	1.166	0.0421	$ 0.132	$0.54		10.4%	9.3%
Anchor-Retail	1.509	0.0089	$ 0.125	$1.44		9.1%	10.0%
K-12	2.255	0.0115	$ 0.185	$2.72		13.4%	14.7%
University	2.106	0.0178	$ 0.180	$2.82		15.6%	16.3%
Warehouse	1.208	0.0037	$ 0.097	$3.11		20.6%	23.9%
Supermarket	1.655	0.0259	$ 0.154	$1.28		4.9%	4.9%
Minimart	1.655	0.0259	$ 0.154	$1.28		4.9%	4.9%
Restaurant	3.417	0.1022	$ 0.366	$0.30		4.2%	3.9%
Lodging	3.603	0.0593	$ 0.337	$2.56		19.7%	19.1%
Hospital	4.594	0.0074	$ 0.361	$2.97		9.3%	11.0%
OtherHealth	3.041	0.0064	$ 0.241	$2.88		10.1%	11.5%
Assembly	1.845	0.0139	$ 0.156	$2.53		11.3%	12.0%
Other	1.845	0.0139	$ 0.156	$2.53		11.3%	12.0%
Total	1.845	0.014	$ 0.156	$2.56		11.2%	12.0%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b

w/406.4 Renewables	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.925	0.0059	$ 0.077	$2.28		9.5%	9.1%
Medium Off	1.246	0.0135	$ 0.110	$2.37		12.9%	11.9%
Small Off	0.657	0.0062	$ 0.057	$1.47		6.8%	6.5%
Big Box-Retail	1.977	0.0089	$ 0.161	$3.61		11.6%	12.9%
Small Box-Retail	1.704	0.0421	$ 0.174	$3.37		12.7%	12.2%
High End-Retail	1.704	0.0421	$ 0.174	$3.37		12.7%	12.2%
Anchor-Retail	1.977	0.0089	$ 0.161	$3.61		11.6%	12.9%
K-12	1.483	0.0231	$ 0.138	$2.54		11.2%	11.0%
University	1.493	0.0273	$ 0.143	$2.42		13.6%	13.0%
Warehouse	0.701	0.0065	$ 0.061	$1.80		13.9%	15.0%
Supermarket	2.338	0.0259	$ 0.206	$4.48		6.3%	6.5%
Minimart	2.338	0.0259	$ 0.206	$4.48		6.3%	6.5%
Restaurant	4.118	0.1022	$ 0.420	$4.52		4.6%	4.5%
Lodging	3.112	0.0669	$ 0.307	$3.07		18.8%	17.4%
Hospital	2.949	0.0428	$ 0.270	$4.14		8.2%	8.3%
OtherHealth	1.950	0.0263	$ 0.177	$3.03		8.5%	8.5%
Assembly	1.401	0.0208	$ 0.129	$2.50		10.1%	10.0%
Other	1.401	0.0208	$ 0.129	$2.50		10.1%	10.0%
Total	1.400	0.020	$ 0.128	$2.52		10.0%	9.9%

Washington Energy Savings: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b							
w/406.5 Envelope	Savings and Cost Per Square Foot						
Building Type	kWh/sf	therm/sf	First Year Savings/ sf	Cost/sf		Site Btu	%carbon
Large Off	0.852	0.0085	$ 0.074	$1.81		9.6%	8.8%
Medium Off	1.233	0.0173	$ 0.112	$1.85		13.6%	12.3%
Small Off	0.638	0.0141	$ 0.063	$0.16		8.5%	7.3%
Big Box-Retail	1.679	0.0226	$ 0.152	$1.77		12.1%	12.3%
Small Box-Retail	1.453	0.0630	$ 0.175	$0.60		14.3%	12.4%
High End-Retail	1.453	0.0630	$ 0.175	$0.60		14.3%	12.4%
Anchor-Retail	1.679	0.0226	$ 0.152	$1.77		12.1%	12.3%
K-12	1.231	0.0361	$ 0.131	$0.83		11.8%	10.6%
University	1.298	0.0379	$ 0.138	$0.98		14.3%	12.7%
Warehouse	0.573	0.0103	$ 0.055	$1.18		13.7%	13.6%
Supermarket	1.677	0.0364	$ 0.166	$1.46		5.6%	5.3%
Minimart	1.677	0.0364	$ 0.166	$1.46		5.6%	5.3%
Restaurant	3.503	0.1246	$ 0.396	$0.34		4.7%	4.2%
Lodging	2.716	0.0734	$ 0.283	$0.59		18.0%	16.1%
Hospital	2.344	0.0563	$ 0.237	$1.29		7.8%	7.4%
OtherHealth	1.639	0.0360	$ 0.163	$1.15		8.4%	7.9%
Assembly	1.195	0.0299	$ 0.122	$1.04		10.4%	9.6%
Other	1.195	0.0299	$ 0.122	$1.04		10.4%	9.6%
Total	1.194	0.029	$ 0.122	$1.07		10.3%	9.5%

Appendix C: First Cost Per Square Foot of Floor Area

The following three tables provide first cost data by building type and climate zone. This includes change from WSEC climate zone 1 to IECC 4c, from WSEC climate zone 1 to IECC 5b and from WSEC climate zone 2 to IECC 5b.

For each code change considered, the following cost was added to the cost of construction for the reference prototype.

Cost per Square Foot of Floor Area: 2009 WSEC to IECC 2012, Zone 1 to Zone 4c

	LPD Changes	Envelope Changes	2010 Equipment Efficiency EER Changes.	Base Code Package Terminal Heat Pump Efficiency	Minimum Skylight Area	Commissioning	Bi-level Lighting Controls	Egress Light Control Reduction (WA)	New Fan Power Requirements (WA)	Metering	Extra Efficiency - HVAC Equipment	Extra Efficiency - Lighting Control	Extra Efficiency - Renewables (PV Assumed)	Extra Efficiency - Envelope
	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf
Grocery with HR	-	0.367	-	-	0.549	-	-	-	0.005	0.465	1.230	-	-	0.168
Grocery	0.002	0.367	-	-	0.549	0.043	0.012	-	0.005	0.465	1.439	-	2.919	0.168
Health Outpatient	-	0.309	-	-	-	-	-	-	0.040	0.405	0.627	-	-	0.196
Hospital	0.005	0.357	-	-	-	0.042	0.025	-	0.050	0.510	0.248	2.000	3.175	0.249
Lodging - Hotel	0.003	0.108	-	-	-	0.026	-	-	0.024	0.489	0.726	2.000	3.058	0.097
Lodging - Motel	0.003	0.108	-	-	-	0.023	0.008	-	-	0.489	0.732	2.000	1.497	0.097
Office - Large	0.007	0.862	-	-	-	0.014	0.057	(0.080)	0.050	0.510	0.576	2.000	0.720	0.369
Office - Medium	0.017	0.862	-	-	-	0.015	0.090	(0.080)	0.050	0.510	0.581	2.000	0.783	0.369
Office - Small	0.012	0.155	-	-	-	0.092	0.027	-	-	-	1.329	2.000	1.058	0.209
Rest-Full Serve	0.087	0.165	-	-	-	0.192	-	-	-	-	1.174	-	4.223	0.226
Rest - Fast food	0.087	0.165	-	-	-	0.192	-	-	-	-	1.200	-	4.223	0.226
Retail - Large	0.014	0.617	-	-	0.605	0.008	0.007	-	0.005	0.510	1.224	-	1.741	0.292
Retail - Small	0.020	0.275	-	-	0.093	0.218	0.075	-	-	-	1.388	-	2.275	0.087
School - Primary	0.009	0.252	-	-	0.057	0.019	0.043	(0.080)	0.049	0.497	0.521	2.000	1.676	0.120
School - Secondary	0.009	0.252	-	-	0.057	0.019	0.015	(0.080)	0.049	0.497	0.524	2.000	1.365	0.120
Warehouse	0.010	0.347	-	-	0.213	0.147	-	-	-	0.510	0.245	2.000	1.156	0.239
Warehouse Semiheated	0.009	0.540	-	-	0.213	0.147	-	-	-	0.510	0.248	2.000	0.406	0.036
Warehouse Unheated	0.009	-	-	-	0.213	0.147	-	-	-	0.510	0.251	2.000	0.416	-

Cost per Square Foot of Floor Area: 2009 WSEC to IECC 2012, Zone 1 to Zone 5b														
	LPD Changes	Envelope Changes	2010 Equipment Efficiency EER Changes.	Base Code Package Terminal Heat Pump Efficiency	Minimum Skylight Area	Commissioning	Bi-level Lighting Controls	Egress Light Control Reduction (WA)	New Fan Power Requirements (WA)	Metering	Extra Efficiency - HVAC Equipment	Extra Efficiency - Lighting Control	Extra Efficiency - Renewables (PV Assumed)	Extra Efficiency - Envelope
	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf
Grocery with HR	-	0.367	-	-	0.549	-	-	-	0.005	0.465	1.230	-	-	0.168
Grocery	0.002	0.367	-	-	0.549	0.043	0.012	-	0.005	0.465	1.439	-	2.919	0.168
Health Outpatient	-	0.309	-	-	-	-	-	-	0.040	0.405	0.627	-	-	0.196
Hospital	0.005	0.357	-	-	-	0.042	0.025	-	0.050	0.510	0.248	2.000	3.175	0.249
Lodging - Hotel	0.003	0.108	-	-	-	0.026	-	-	0.024	0.489	0.726	2.000	3.058	0.097
Lodging - Motel	0.003	0.108	-	-	-	0.023	0.008	-	-	0.489	0.732	2.000	1.497	0.097
Office - Large	0.007	0.862	-	-	-	0.014	0.057	(0.080)	0.050	0.510	0.576	2.000	0.720	0.369
Office - Medium	0.017	0.862	-	-	-	0.015	0.090	(0.080)	0.050	0.510	0.581	2.000	0.783	0.369
Office - Small	0.012	0.155	-	-	-	0.092	0.027	-	-	-	1.329	2.000	1.058	0.209
Rest-Full Serve	0.087	0.165	-	-	-	0.192	-	-	-	-	1.174	-	4.223	0.226
Rest - Fast food	0.087	0.165	-	-	-	0.192	-	-	-	-	1.200	-	4.223	0.226
Retail - Large	0.014	0.617	-	-	0.605	0.008	0.007	-	0.005	0.510	1.224	-	1.741	0.292
Retail - Small	0.020	0.275	-	-	0.093	0.218	0.075	-	-	-	1.388	-	2.275	0.087
School - Primary	0.009	0.252	-	-	0.057	0.019	0.043	(0.080)	0.049	0.497	0.521	2.000	1.676	0.120
School - Secondary	0.009	0.252	-	-	0.057	0.019	0.015	(0.080)	0.049	0.497	0.524	2.000	1.365	0.120
Warehouse	0.010	0.347	-	-	0.213	0.147	-	-	-	0.510	0.245	2.000	1.156	0.239
Warehouse Semiheated	0.009	0.540	-	-	0.213	0.147	-	-	-	0.510	0.248	2.000	0.406	0.036
Warehouse Unheated	0.009	-	-	-	0.213	0.147	-	-	-	0.510	0.251	2.000	0.416	-

Cost per Square Foot of Floor Area: 2009 WSEC to IECC 2012, Zone 2 to Zone 5b														
	LPD Changes	Envelope Changes	2010 Equipment Efficiency EER Changes.	Base Code Package Terminal Heat Pump Efficiency	Minimum Skylight Area	Commissioning	Bi-level Lighting Controls	Egress Light Control Reduction (WA)	New Fan Power Requirements (WA)	Metering	Extra Efficiency - HVAC Equipment	Extra Efficiency - Lighting Control	Extra Efficiency - Renewables (PV Assumed)	Extra Efficiency - Envelope
	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf	$/sf
Grocery with HR	-	0.201	-	-	0.549	-	-	-	0.005	0.465	1.230	-	-	0.183
Grocery	0.002	0.201	-	-	0.549	0.043	0.012	-	0.005	0.465	1.476	-	3.205	0.183
Health Outpatient	-	0.241	-	-	-	-	-	-	0.040	0.405	0.627	-	-	0.194
Hospital	0.005	0.333	-	-	-	0.042	0.025	-	0.050	0.510	0.284	2.000	3.175	0.320
Lodging - Hotel	0.003	0.027	-	-	-	0.026	-	-	0.024	0.489	0.747	2.000	3.294	0.035
Lodging - Motel	0.003	0.027	-	-	-	0.023	0.008	-	-	0.489	0.740	2.000	1.732	0.035
Office - Large	0.007	0.848	-	-	-	0.014	0.057	(0.080)	0.050	0.510	0.586	2.000	0.871	0.401
Office - Medium	0.017	0.848	-	-	-	0.015	0.090	(0.080)	0.050	0.510	0.582	2.000	0.918	0.401
Office - Small	0.012	0.010	-	-	-	0.092	0.027	-	-	-	1.329	2.000	1.329	0.018
Rest-Full Serve	0.087	0.019	-	-	-	0.192	-	-	-	-	1.283	-	4.223	0.038
Rest - Fast food	0.087	0.019	-	-	-	0.192	-	-	-	-	1.488	-	4.223	0.038
Retail - Large	0.014	0.296	-	-	0.605	0.008	0.007	-	0.005	0.510	1.258	-	2.163	0.323
Retail - Small	0.020	0.130	-	-	0.093	0.218	0.075	-	-	-	1.405	-	2.838	0.060
School - Primary	0.009	0.145	-	-	0.057	0.019	0.043	(0.080)	0.049	0.497	0.574	2.000	2.007	0.104
School - Secondary	0.009	0.145	-	-	0.057	0.019	0.015	(0.080)	0.049	0.497	0.580	2.000	1.635	0.104
Warehouse	0.010	0.253	-	-	0.213	0.147	-	-	-	0.510	0.265	2.000	1.323	0.211
Warehouse Semiheated	0.009	0.523	-	-	0.213	0.147	-	-	-	0.510	0.269	2.000	0.426	0.036
Warehouse Unheated	0.009	-	-	-	0.213	0.147	-	-	-	0.510	0.262	2.000	0.431	-

Appendix D. Measure Evaluation Details

Envelope Insulation

The proposal changes are mixed with many Zone 1 values improved , especially mass walls, but some Zone 2 requirements are reduced.

The proposal also reduces the maximum allowed fenestration to 30% of gross wall area. 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. The savings from the alternative response of installing less glass will be very similar. However on the cost side the alternative response would likely be reduced cost rather than the increased cost 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.

Table 4 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 4. Envelope Data Summary (UA/ft²). NEEA New Construction Survey

Zone	Code Heat loss Rate (UA/ft^2)		Modeled ΔUA[1] (UA/ft^2)	Cost ($/ft^2)
	Current Code	Future Code		
Zone 1 to IECC 4c/5b	0.154	0.126	-0.028	0.455
Zone 2 to IECC 5b	0.147	0.126	-0.021	0.320

[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 for the BPA Next Generation codes project. 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 5 presents the cost for various envelope component changes. Table 6 contains cost data for fenestration increments.

Table 5. Opaque Envelope Costs ($/ft²).

Comp.	Item	Increment	Cost ($/ft²)	Notes[1]
Door	Sliding	U0.60 to R4.75	1.58	WZ: Insulated door cost - $1.35/ft²
	Swing	U0.60 to U0.37	1.05	Use WZ U0.7 to U0.37 cost
Floor	Frame	steel - R38+R4/U0.029 to R30/U0.029		Assumed no change.
		wood - R30/U0.029 to R30/U0.029	—	No change.
	Mass	R30/U0.029 to R30/U0.031	—	Assumed no change.
	Slab	Non Res R10/F0.54 to R15/F0.0528, Res Non Res R10/F0.54 to R20/F0.51	0.60	Eco: Added 1" of insulation (XPS) at about & $.30/sf ~2 sf per linear ft so $0.60
	Slab, Heated	R10ci/F0.36 to R10ci/F0.55	—	No change. F difference is result of different chapter 10 reference.
Roof	Attic Other	R49/U0.027 to R49/U0.021	0.00	No change.
	Metal Bldg	No change	0.00	No change
	Roof deck	R30/U0.034 to R30/U0.034	—	No change
Skylight		Without curb, U0.5 to U 0.5. With curb could be reduction but that not evaluated here.	—	No change
Wall	Below Grade		—	same as above grade mass wall
			—	same as above grade mass wall
Mass Wall, Option 1	Mass	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
		R7.6/U0.123 to R13.3/U0.078	0.70	Eco: $.70 for 1" of insulation and labor and mark-up. It assumes that the remaining features of the wall are unchanged by this addition.

Comp.	Item	Increment	Cost ($/ft^2)	Notes[1]
	CMU	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.
		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.
Mass Wall, Option 2	Mass	R5.7/U0.15 to R9.5/U0.104	0.46	
		R7.6/U0.123 to R9.5/U0.104	0.244	
	CMU	Corefill to Corefill	0.0	No Change
		R7.6/U0.123 to corefill	-2.05	
Wall	Metal, building	R13+7.5/U0.064 to R13+13/U0.052	1.053	WZ: $0.90
	Metal, frame	R13+7.5/U0.064 to R13+10/U0.055	0.322	WZ: $0.275 material cost of added R2.5
	Wood Frame	R21/U0.057 to R21int/U0.054	—	framing change, no change in cost. Assume more material but less time so a wash.
		R21+R2.5/U0.051 to R21/U0.054	-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 plus markup.

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

Table 6. Fenestration Costs ($/ft^2).

Window Type	Increment	Cost ($/ft^2)	Notes
Non-metal, fixed	U0.32 to U0.30	0.40	Add argon. Also possible to get with an "improved Low-e" same cost range.
Non-metal, operable	U0.32 to U0.30	0.40	Add argon
Metal, fixed	U0.40 to U0.38	0.40	Add argon
Metal, operable	U0.40 to U0.40	0	No change
Metal entrance	U0.60 to U0.60	0	No change

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

The proposed maximum vertical glazing is 30% unless 50% of the floor area is in a daylight zone with automatic daylight controls, in which case the maximum is 40%. The NEEA New Construction Survey

data has poor information to determine the percentage of floor are which could physically qualify for the higher glazing fraction. An optimally shaped space with 14' floor-to-ceiling would have a wall to floor ratio of 0.47. So it is assumed that NEEA Baseline buildings 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 required by code. 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%. 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.

Addition Efficiency Option - Envelope

The envelope option requires a building have prescriptive values 15% over the standard envelope parameters. The evaluation assumes all opaque components had improved insulation by 15% and that window thermal performance improved by 15% as well. 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 envelope 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. This is likely a gross over-estimate of the cost in buildings following this path.

Air Barrier

The 2012 WSEC proposal introduces more explicit requirements for a building air barrier. It requires buildings to use 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 2009 WSEC requires extensive sealing in all buildings. And 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, does the new language change anything? Plywood sheeting would need to have seams sealed if it were the air barrier, but GWB also can be the air barrier and in most cases probably would be chosen rather than sealing the plywood. CMU blocks must be sealed in the new language. This is new but it is common practice to seal CMU blocks from moisture incursion.

No change has been assumed for this language.

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.

PTHP Heating Efficiency

The federal minimum heating efficiency requirements for PTHP equipment increased as of October 8, 2012. With the federal minimum efficiency standards, PTHP efficiency requirements increase by approximately 6%. No cost is assumed since this is based upon federal minimum efficiency standards.

Additional Efficiency Option HVAC Equipment Efficiency

Buildings following the high-efficiency HVAC option must comply with the minimum efficiency requirements in table C406.2 (high-efficiency path table), or if not listed in C406.2 be 10% better performing than the base code equipment performance requirements. In addition, non-regulated equipment such as resistance heaters are limited to no more than 5% of the heating and/or cooling capacity.

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.

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 code to code shift in cooling efficiency. All equipment as assumed to qualify for the path.

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 code to code 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 data is so out-of-date and because it is likely equipment cost has changed for reasons other than inflation, perhaps even decreasing.

HVAC System Fan Power

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.

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.

Further research of available baseline information is recommended. A discussion of the research for this measure 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 7 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 shows an inconsistent 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 7. 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.

Lighting Power Allowance

The change in maximum lighting power allowance using the building area method was evaluated. The maximum allowances decrease slightly in most cases.

The proposal introduces an alternate space-by-space lighting power allowance 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 (decreasing efficiency) for some portion of projects.

There is also a large disconnect between the allowances of building path and the space-by-space path which will likely result in significant erosion of savings from even the current code in some building types. This is particularly true in restaurants and warehouse where the space-by-space allowances for most all areas are substantially above the building allowance.

The space-by-space path is not evaluated.

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

Table 8 provides summary LPD values modeled.

Table 8. Average LPD Inputs (W/ft²). NEEA New Construction Survey[1]

Average Code Required LPD (W/ft^2)	
Base Code	Future Code
1.056	0.991

1 – Average LPD for all building in baseline study

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 for each of these lighting technologies. 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 9. Average Cost of LPD Reduction (W/ft^2). NEEA New Construction [1]

Average Code LPD Reduction
($/ft^2)
0.011

1 – Average Cost for all building in baseline study

Lighting Controls – Bi-level

The proposal has requirements for bi-level lighting controls in spaces that do not require occupancy controls or daylight controls. The controls must be able to switch off 50% of the lighting power in a room or space. Exempt from this are corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms, sleeping areas, patient rooms, and spaces with <0.6w/sf. So this probably applies <10% of the lighting in typical buildings

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.

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

Minimum Skylight and Daylight Controls

The code requires skylights in enclosed Zone 4c/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 automatic daylight control. 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.

Commissioning

The proposal extends building commissioning requirements for the mechanical and lighting systems to small buildings that previously were exempted due to have cooling capacity <40 tons, and heating capacity <600,000kBtuh. There are also added requirements for commissioning of service water heating systems.

The potential energy savings for this 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. 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 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.

Cost Estimate

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.

Metering

This proposal adds a requirement for metering of source energy plus submetering of HVAC and water heating energy for buildings over 20,000 sf. Almost all buildings over 20,000 sf get data collection and display systems installed, typically with four or five required data points: pulse output from gas and electric utility meters, and submetering for water heating and HVAC. The HVAC could have submetering for both gas and electric. Buildings with HVAC components distributed in multiple locations may require additional submeters and associated wiring.

Costs were based upon pricing estimates from suppliers for the building interface and pulse inputs. The number of added monitoring points required for HVAC equipment were determined based on the square footage of buildings for different PNNL prototypes and approximate air handling equipment amount for building prototypes . Buildings that have metering installed were used to check some of the pricing and it was found to correlate well. Metering in many cases can be integrated with the building automation system (BAS) resulting in a lower cost for the interface and pulse meter inputs. The integration of the metering system into BAS results in less cost for the metering system. The base cost for metering interface and pulse impulse is approximately \$15,000 to \$22,000 with monitoring points with a cost of \$300 a point. By integrating the metering system with the BAS a cost reduction of \$5,000 to \$9,000 can be achieved with the interface and pulse inputs with the monitoring points remaining the same.

Additional Efficiency – Advanced Lighting Controls Option

This path requires projects to install advanced lighting controls including individually addressable ballasts. The savings from this path are potentially very large and also highly uncertain. Savings were modeled in all building types.

Additional Efficiency – Renewables Option

This option requires renewable capacity of 1.75 BTU/ft^2; or 0.5 W/$ft^{2.}$ The analysis of this measure assumed photovoltaic cells are installed and that they will operate with a 16% load factor.

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.

Appendix E: Financial Inputs

The following inputs were used throughout this document to provide energy cost, internal rate of return or cost benefit ratio.

Commercial

Electric Cost (kWh)	$ 0.077
Natural Gas Cost (Therm)	$ 1.010

Energy cost including state and local taxes

Discount Rate (% Real)	7.60%
Loan Rate (%)	3%
Loan Term (years)	20
Loan to Value (%)	0.85

Inflation Rates (%)

General	2.0%
Electricity	1.7%
Gas	3.2%
O&M	2.0%
Capital Purchases	2.0%