ECOTOPE
CONSULTING
RESEARCH
DESIGN

4056 9TH AVENUE NE SEATTLE, WA 98105
(206) 322-3753 FAX: (206) 325-7270

Date: September 6, 2012
To: Chuck Murray, Washington State Department of Commerce
David Cohan, Northwest Energy Efficiency Alliance
From: Ben Larson and David Baylon, Ecotope Inc.
Re: Residential WSEC 2012 Energy and Cost Analysis

Overview and Key Assumptions

Ecotope has completed energy and cost analyses of the residential portion of the 2012 Washington State Energy Code (WSEC). Ecotope conducted building modeling to predict the energy use of houses constructed under both the 2009 and proposed 2012 energy codes. The difference between the two constitutes the incremental energy savings of the new code. Likewise, Ecotope estimate the incremental capital costs of the energy efficiency improvements in the new code.

To conduct the analysis, Ecotope made key assumptions about which options in 2009 houses used to meet that energy code. For mid-size gas furnace and heat pump options, we asserted the houses used option 1a, the high efficiency HVAC equipment, from Table 9-1 in the 2009 WSEC. For mid-size houses that are heated with zonal electric resistance, we asserted the houses used option 3b, efficient building envelope 2. For houses less than 1500 ft^2 in floor area, no options are needed. Ecotope did not model the large houses greater than 5000ft^2 in floor area because they make up a small fraction of the overall building market.

The assumptions setting the baseline are integral to the entire analysis. All energy savings are calculated relative to those baselines in 2009. Likewise, all incremental costs are calculated to the same baseline.

Results

Using a weighted combination of building sizes and HVAC systems to represent all new residential construction in the state, the analysis shows a likely range of energy savings and costs per house built including:

- Electricity saved vs 2009 for each house: 669-681 kWh/yr
- Natural gas saved vs 2009 for each house: 42-44 therms/yr
- Total site energy use reduction vs 2009: 9.6-9.8%
- Incremental first cost of: $678-$790

Table 1 presents the results in a more granular basis for the mid-size and small houses with three heating system types for a selected combination of option and compliance paths.

Table 1. Selected Combinations: Energy and Costs

		Savings vs 2009			Incremental Cost	Simple Payback
Prototype	**Heating Type**	**kWh/yr**	**therms/yr**	**%**	**$**	**years**
Mid-Size House	Gas Furnace	642	51	10%	$ 768	6.6
Small House		679	43	12%	$ 230	2.1
Mid-Size House	Heat Pump	1054	0	8%	$ 77	0.9
Small House		868	0	8%	$ -	0.0
Small House	Elec. Res. Zonal	671	0	6%	$ 77	1.4

Table 3 presents detailed results for a multitude of compliance paths for the 2012 code. The labeling code for Table 3 is given in Table 2. Each house size and heating system type has a different set of options available to attain the 0.5 or 1.5 points needed for code compliance. The large combination of possibilities leads to the large number of rows in Table 3. Not every possibility is presented in Table 3, however, the most likely combinations are. Further, to determine what the overall, statewide energy savings might be, Ecotope estimated the frequency with which each compliance path may occur. We created two scenarios depicted in the columns BL1 and DB1.

Table 2. Labeling Code for Table 3.

Heating Systems		
gfnc	Gas Furnace No Cooling	
gfac	Gas Furnace with Cental Cooling	
hp77	Heat Pump HSPF 7.7	
hp85	Heat Pump HSPF 8.5	
zonl	Zonal Resistance Heat	
Code Options (Table 406.2)		
Option	**Description**	**Credits**
1a	envelope a	0.5
1b	envelope b	1
1c	envelope c	2
2a	exhaust fan	0.5
2b	hrv b	1
2c	hrv c	1.5
3a	95 AFUE (gas only)	0.5
3b	8.5 HSPF (hp only)	1
3d	dhp (zonal only)	1
4_	ducts inside	1
5a	dhw low flow better tank	0.5
5b	hpwh or gas tankless	1.5
6_	renewables onsite	0.5

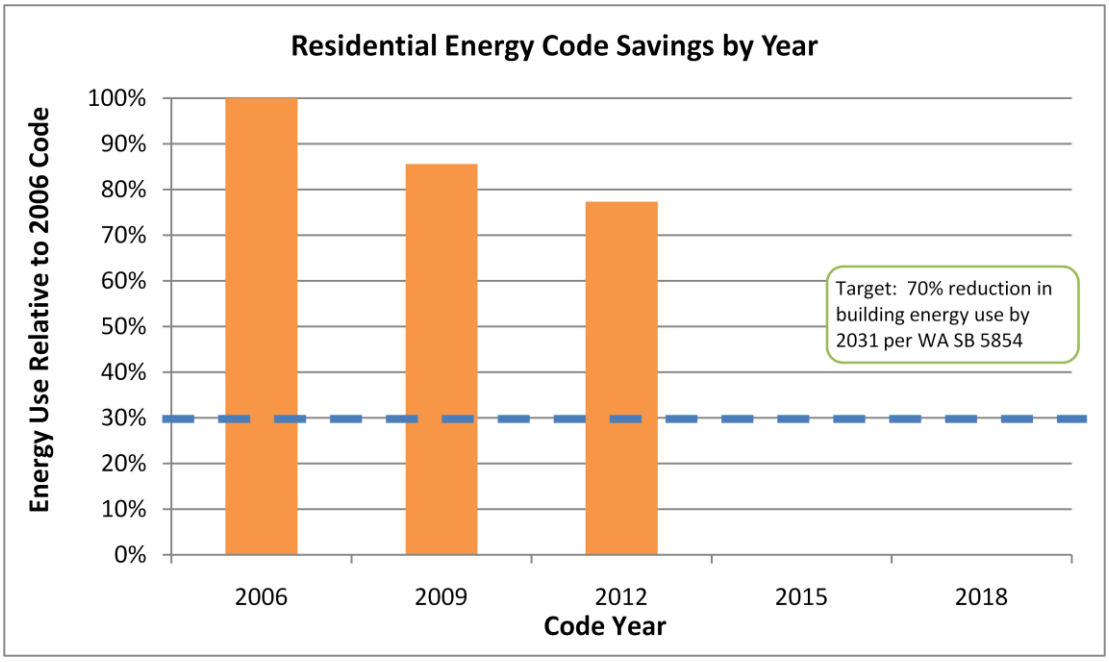
Table 2. WSEC 2012 Energy Savings and Cost vs 2009

House Size	House Heating System	Options Combinations	Savings vs 2009			Incremental Cost	Options Weighting	
			kWh/yr/house	therms/yr/house	Total		BL1	DB1
Medium Size House - needs 1.5 pts (83% of population)	Gas Furnace No Cooling	gfnc_1a_2a_5a	861	58	11.6%	$ 1,595	0.05	0.075
		gfnc_3a_1a_2a	861	51	10.7%	$ 1,826	0.05	0.05
		gfnc_3a_1a_5a	394	83	12.9%	$ 1,313	0.2	0.125
		gfnc_3a_2a_5a	861	41	9.4%	$ 743	0.3	0.25
		gfnc_1a_2b___	376	71	11.2%	$ 3,253	0	0.025
		gfnc_1a_4____	393	57	9.4%	$ 1,383	0	0.025
		gfnc_1b_2a___	861	76	14.1%	$ 3,314	0	0.025
		gfnc_1b_5a___	389	108	16.3%	$ 2,801	0	0.025
		gfnc_2a_4____	861	14	5.8%	$ 813	0.1	0.05
		gfnc_3a_4____	397	40	7.2%	$ 530	0.1	0.1
		gfnc_4__5a___	397	46	8.0%	$ 300	0.1	0.15
		gfnc_5b_____	398	77	12.1%	$ 716	0.1	0.1
	Gas Furnace with CAC	gfac_1a_2a_5a	832	57	11.2%	$ 1,595	0.05	0.075
		gfac_3a_1a_2a	832	50	10.3%	$ 1,826	0.05	0.05
		gfac_3a_1a_5a	377	82	12.5%	$ 1,313	0.2	0.125
		gfac_3a_2a_5a	868	41	9.2%	$ 743	0.3	0.25
		gfac_1a_2b___	305	70	10.5%	$ 3,253	0	0.025
		gfac_1a_4____	393	55	9.0%	$ 1,383	0	0.025
		gfac_1b_2a___	799	75	13.4%	$ 3,314	0	0.025
		gfac_1b_5a___	338	107	15.6%	$ 2,801	0	0.025
		gfac_2a_4____	884	13	5.7%	$ 813	0.1	0.05
		gfac_3a_4____	431	40	7.1%	$ 530	0.1	0.1
		gfac_4__5a___	431	46	7.9%	$ 300	0.1	0.15
		gfac_5b_____	417	77	11.9%	$ 716	0.1	0.1
	Heat Pump	hp85_3b_5a___	1054	0	7.6%	$ 77	0.7	0.7
		hp77_2a_4____	850	0	6.1%	$ 813	0.1	0.1
		hp77_4__5a___	1025	0	7.4%	$ 377	0.2	0.2
	Zonal Resistance Heat	zonl_1b_2a___	239	0	1.7%	$ 513	0.5	0.4
		zonl_1b_5a___	832	0	6.0%	$ 77	0.5	0.5
		zonl_2a_3d___	1433	0	10.2%	$ 3,313	0	0.05
		zonl_3d_5a___	1985	0	14.1%	$ 2,877	0	0.05
Small House - needs 0.5 pts (15% of population)	gfnc	gfnc_3a_____	679	43	12.4%	$ 230	0.5	0.5
		gfnc_5a_____	679	49	13.6%	$ -	0.5	0.5
	gfac	gfac_3a_____	672	43	12.0%	$ 230	0.5	0.5
		gfac_5a_____	672	49	13.2%	$ -	0.5	0.5
	Heat Pump	hp77_2a_____	728	0	6.9%	$ 327	0.2	0.2
		hp85_3b_____	868	0	8.2%	$ -	0.4	0.4
		hp77_5a_____	951	0	9.0%	$ 77	0.4	0.4
	zonl	zonl_2a_____	135	0	1.3%	$ 327	0.2	0.2
		zonl_5a_____	671	0	6.3%	$ 77	0.8	0.8
					Overall kWh/yr/house Savings		**681**	**669**
					Overall therms/yr/house Savings		**42**	**44**
					Overall Total Energy Percent Savings		**9.6%**	**9.8%**
					Overall Cost		**$ 678**	**$ 790**

Comparison to Previous Codes

Figure 1 compares the relative energy use of each of three versions of the WSEC starting with 2006 as the reference year. With each iteration, the code has produced more energy efficient buildings. The estimates of energy use for 2006 and 2009 were based on previous work conducted by Ecotope for NEEA.[1]

Figure 1. Comparison to Previous Codes



Energy Analysis - Simulation Approach

The analysis approach used is similar to that for analyses of previous WSEC changes by Ecotope and the same methodology approved by the Regional Technical Forum to estimate savings of the proposed 2011 ORSC[2]. Where necessary, it has been adapted to suit the current codes. Broadly, the analysis methodology is to develop a representative set of prototypical houses whose energy use can be estimated through simulation tools. These representative characteristics include climate, occupancy, house size, ground contact type (slab, crawl, or basement), and heating system type.

The building energy use was predicted by a combination of numerical simulations and engineering calculations. SEEM (Simplified Energy and Enthalpy Model) was used to simulate heating, cooling, and ventilation energy use. The program combines building shell characteristics, thermostat settings, occupant behavior inputs, descriptions of heating and cooling systems, and duct distribution efficiency to develop an overall estimate of energy requirements of a house. Additionally, engineering calculations

[1] http://neea.org/docs/reports/2011-residential-codes-energy-use-savings.pdf?sfvrsn=18
http://neea.org/docs/default-document-library/2011-residential-codes-energy-use-savings---appendix-b.xlsx?sfvrsn=8

[2] RTF Meeting 9/2010. http://www.nwcouncil.org/energy/rtf/meetings/2010/09/Default.htm

calibrated by field studies were employed to determine the energy use for lighting and water heating. Lighting energy calculations were done using a lighting power density method corresponding to the level of regular and high efficacy lights required by the codes. This method assumes all lamps in the house operate 1.5 hours per day throughout the year[3]. Water heating energy was calibrated to the equivalent of 18 gals per day per occupant[4]. Single family occupancy is 2.5 people/house. The loads not regulated by the code, including appliances and plug loads are assigned a constant value of 4,000 kWh/yr for both the 2009 and 2012 codes.

SEEM (version 0.94), the residential energy-simulation program used for the analysis was developed by and for the Northwest Power and Conservation Council and the Northwest Energy Efficiency Alliance (NEEA), and written by Larry Palmiter of Ecotope. It is the simulation engine used to provide heating and cooling energy savings estimates for the residential sector in the Northwest Power Plan, for the Performance Tested Comfort System (PTCS) incentive program, as well as numerous other utility program offerings. SEEM is also used extensively to support state building energy code revisions including, most recently, the revised Washington State Energy Code and Oregon Residential Specialty Code.

The SEEM program consists of an hourly thermal, moisture (humidity), and infiltration simulation that interact with ducts, equipment, building shell and weather parameters to calculate the space conditioning requirements of the building. It is based on algorithms consistent with current American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), American Heating and Refrigeration Institute (AHRI), and International Organization for Standards (ISO) calculation standards. The simulation generates outputs used in this analysis; they include building heat loss (UA), heating equipment input energy, cooling equipment input energy, and ventilation equipment input energy.

The weather files used in all savings simulations include Seattle for IECC zone 4 marine and Spokane for IECC zone 5.

Three distinct building prototypes were used in the SEEM simulations: a 1344 ft^2 (square foot) ranch style home, a 2200 ft^2 split level home, and a 2688 ft^2 home with a full conditioned basement. These are standard analytical prototypes used by the Northwest Power and Conservation Council to develop and evaluate energy forecasts and conservation plans for the region's utilities.

The 1344 ft^2 and 2200 ft^2 prototypes are split further into crawl space or slab-on-grade construction. Next, each prototype is assigned a weight in proportion to its frequency of occurrence in the building population. By creating a weighted average of prototypes, a single estimate is made to represent the energy use of constructing a new house in a Washington. Accounting for the different ground contact possibilities there are five prototypes used to describe the single family house (1344 crawl and slab, 2200 crawl and slab, 2688 basement).

[3] RTF Meeting 9/2010: http://www.nwcouncil.org/energy/rtf/meetings/2010/09/Default.htm

[4] RTF provisionally approved savings measure: http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=176