2009 Washington State Energy Code Changes: Analysis of Major Single Family Proposals

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Executive Summary

This paper provides consumer cash flow analysis of a key set of proposed amendments to the residential sections of the Washington State Energy Code. This analysis is based on the proposals moved into rulemaking by the State Building Code Council, WSR 09-05-054. This paper provides a detailed description of the energy code changes analyzed. This is followed by an energy savings analysis, a first cost analysis, and a consumer cash flow analysis.

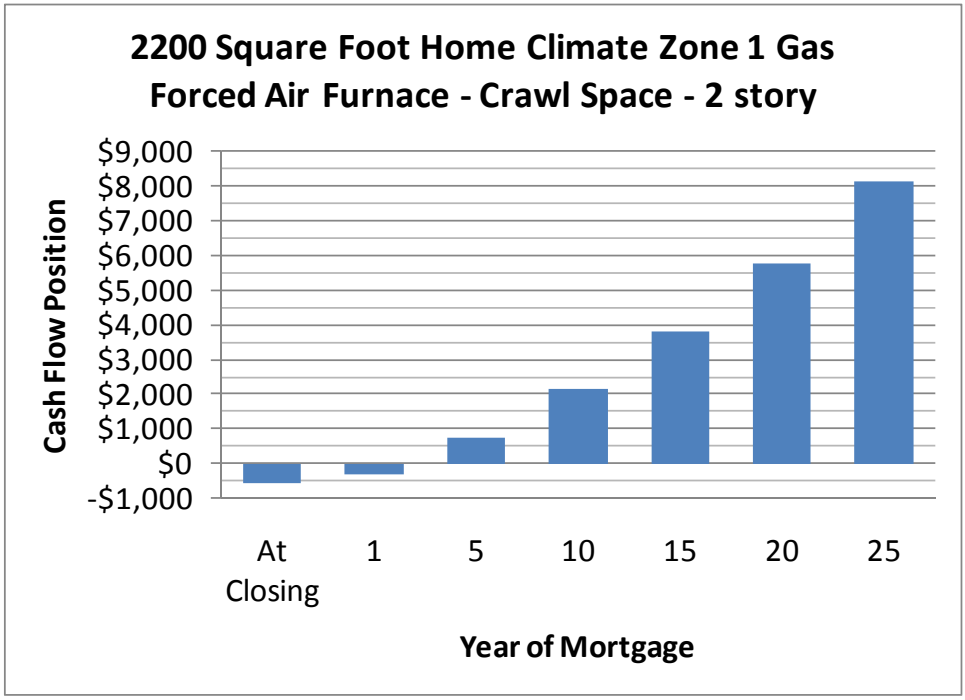
First cost range from $0.89 to $1.47 per square foot, depending on building size and heating system type. For average size gas heated homes, representing 75% of all new homes in Washington, the cost will be $0.99 to $1.24 per square foot. First cost is based on large data sets of information that have been through public review such as the Northwest Power Planning Council Sixth Power Plan estimates or the Department of Energy's rule making processes.

The energy savings analysis shows savings for the average size gas heated home of 26 percent. Savings in other prototypes show somewhat less savings.

The final consumer cash flow analysis is based on a home purchased with a conventional 30 year mortgage. Each year the resulting cash flow position of the home owner is represented as the difference between the cumulative cost (down payment + mortgage) and cumulative savings (energy). At the end of the first winter, the consumer will begin to benefit from a reduced cost of ownership. Positive cash flow varies from project to project. But the majority of home buyers will be in a positive cash flow position by the end of the third year of ownership. The down payment will be fully recaptured by this time. Savings will increase as energy cost increase – while the cost of the mortgage will remain the same over time.

The following figure, Example Cash Flow, provides an example of the cash flow for a 2200 SF gas heated home located in Seattle. Additional graphs for the other prototypes are included in Appendix A. The simplified cash flow summary for all prototypes is represented in the Table, Consumer Cash Flow Summary.

Example Cash Flow



Consumer Cash Flow Summary

House size	Heating System	Home Owner Cash Flow		
Climate Zone 1		**Year of home ownership**		
		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	$ 722	$ 2,125	$ 3,827
	Heat Pump	$ 351	$ 1,496	$ 2,903
1350 SF, Crawlspace	Gas Furnace	$ 69	$ 577	$ 1,221
	Heat Pump	$ 54	$ 587	$ 1,258
	Zonal (electric)	$ (123)	$ 128	$ 464
5001 SF, 2 stories, Basement	Gas Furnace	$ 35	$ 1,360	$ 3,059
	Heat Pump	$ (503)	$ 298	$ 1,387
Climate Zone 2		**Year of home ownership**		
		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	$ 1,520	$ 3,653	$ 6,178
	Heat Pump	$ 1,849	$ 4,570	$ 7,704
1350 SF, Crawlspace	Gas Furnace	$ 454	$ 1,281	$ 2,279
	Heat Pump	$ 750	$ 1,948	$ 3,364
	Zonal (electric)	$ 82	$ 459	$ 927
5001 SF, 2 stories, Basement	Gas Furnace	$ 441	$ 2,084	$ 6,538
	Heat Pump	$ 310	$ 1,882	$ 3,836

Introduction

The Washington State Department of Commerce proposed a number of changes to the Washington State Energy Code during the 2009 state energy code development cycle. These changes aimed to accomplish roughly a 30% reduction in energy consumption in new housing compared to the 2006 Washington State Energy Code. These proposals have since been modified by the State Building Code Council Energy Code Tag. On August 19, 2009, the council moved the Tag recommendations into formal rulemaking as WSR 09-05-054. The comments in this report are based on this edition of the code changes.

This paper is focused on presenting a cash flow analysis of the proposed code changes. The proposed changes will add to the cost of construction. But the energy savings resulting from these investments will reduce operating cost to the home owner. The result will be reduced overall cost to the home owner.

This paper provides a detailed description of the energy code changes analyzed in this paper. This is followed by an energy savings analysis, a first cost analysis, and a consumer cash flow analysis.

Proposed Code Changes

For single family homes, the energy saving measures included in the 2006 WSEC are primarily focused on building insulation, windows and prescriptive air leakage control. In 2007, the SBCC took the first major departure from this when it approved the proposal for duct leakage testing.

While there are still some cost effective building envelope measures that have yet to be adopted, many of the most cost effective building methods will come from the adoption of new measures. This includes improved space heating equipment, improved water heating equipment, designs that further control HVAC system losses to the exterior, performance testing of building air leakage and lighting requirements.

Another characteristic of the 2006 WSEC is that it usually applied as a one size fits all standard. While systems analysis and component trade off approaches exist in the code, the required calculations of these methods are usually avoided. Almost all single family homes are constructed using the prescriptive compliance options. A key component of the Department of Commerce proposal is to increase the options available to builders using a prescriptive code compliance method. Additional flexibility limits the cost impacts of the code by allowing the builder to select the energy efficiency measures that best fits the design of the home and local market conditions.

The conditioned floor area of the home is another aspect of energy consumption that is addressed by the Department of Commerce proposal. Small homes use much less energy than large homes. Because of this, an efficiency measure that is very cost effective in an average size home is not always financially justified in a small home. To counter this effect, the Commerce proposal (as modified by the Energy Code TAG) provides a reduced set of requirements for small homes (less than 1500 sf) and an increased set of requirements for very large homes (more than 5000 sf).

To implement the objectives noted above, the Department of Commerce developed a number of proposals. First there are a number of proposals that apply to all new homes. These are implemented through the existing chapters 5 or 6 of the code. In addition, the proposal requires each project to include one or more additional energy efficiency measures from a menu of options. These requirements have been added to a new Chapter 9. The energy code upgrades to be discussed in this paper apply to the following:

- 09-140 – Chapter 9 – Energy Efficiency Construction Options
- 09-141 – Residential Building Envelope
- 09-080 – Heat Pump Controls
- 09-134 - Building Air Leakage Testing
- 09-135 – HVAC Fan Power Limits
- 09-139 – Residential Lighting

For each of these changes, we have included a reference to the rule making document. These are in brackets.

09-002 Group R (residential) Change in Scope: [Section 101.3 Scope] Before we describe the Commerce proposals, it is important to remind the reader of a change in scope for the WSEC. As a result of direction given by the council, the energy code TAG limited the application of WSEC chapters 1-9 to the single family, duplex and townhomes. The details discussed in this paper only apply to these occupancies.

09-140 – Chapter 9 – Additional Residential Energy Efficiency Requirements: [Section 901, Table 9-1] Chapter 9 requires each project to adopt additional energy efficiency measures for the home. Additional measures are selected from Table 9.1 Energy Credits (Debits). This table lists 14 prescriptive energy efficiency measures. ***Most projects (about 90%) will be required to select two of these options to qualify.*** As an exception to the chapter 9 prescriptive method, the project may comply by demonstrating improved efficiency using the WSEC chapter 4 systems analysis approach.

Using a similar table of optional measures for energy code compliance was first implemented in Oregon in 2008.

- **Options 6, 7. Home Size:** [Section 901, Table 9-1] The number of additional measures required for each project is adjusted based on the floor area of the home. For small homes with 1500 square feet of floor area or less, one additional measure is required. This applies to about six percent of the state housing stock. For very large homes with greater than 5000 square feet three additional measures must be specified for the project. This applies to 2-3 percent of the housing stock. For homes with floor area between 1500 and 5000 square feet, two additional energy conservation measures must be specified for the project.[1] The available options from Table 9-1 follow:

[1] Home floor area distributions based on U.S. Census, American Housing Survey: Seattle Metro Data, 2005.

- **Options 1a, 1b, 1c. High Efficiency HVAC Equipment:** There are a number of options to select improved equipment efficiency as a chapter 9 compliance option. This includes high efficiency furnaces, boilers and several styles of heat pumps. We anticipate that improved equipment efficiency will be selected for many projects because it is the one of the lowest cost measures and does not require modifications to existing home designs.
- **Option 2. High Efficiency HVAC Distribution System:** This option requires that all of the heating equipment and distribution systems (ducts or pipes) be installed inside the insulated building envelope. There is a limited exception that allows up to 5% of the duct system to be in unconditioned space. If this method is used, the duct testing currently required by code is no longer required. This is a very low cost option when the designer considers this requirement as part of the initial planning of the project. Research conducted in Washington State documents this measure as a no cost option under these conditions.[2,3]
- **Options 3a, 3b, 3c. Efficient Building Envelope:** Three options for improved building envelope are included, with the resulting energy improvement providing 0.5 to 2 credits. These options provide an opportunity to reduce building heat loss with better windows and insulation than prescribed in the base code. These options will most likely be used for small electric resistance heated homes.
- **Options 4a, 4b. Air Leakage Control and Efficient Ventilation:** Two options provide the opportunity to obtain credits for improved air leakage control. Over the last 6 years, a number of builders and insulation contractors have been advocating for more opportunities to demonstrate code compliance through improved air leakage control combined with heat recovery ventilation. We do not anticipate that this will be a frequently used option until builders gain some confidence in their air sealing abilities. Once they have some experience, this could become a low cost measure. More information on air leakage control follow in the section describing change 09-134 - Building Air Leakage Testing. Each level of air sealing is accompanied by a prescriptive ventilation system. At the minimum level the ventilation required by the VIAQ code or IMC. The more stringent air sealing standards require an exhaust only ventilation system with an exhaust fan and an efficient motor. This system would be sized as the mandated in the current VIAQ. Finally in the most stringent case the use of a ducted Air-to-air heat exchanger is required.
- **Options 5a, 5b. Efficient Water Heating:** Two options for efficient water heating are offered. One provides 0.50 credits for a minor upgrade in water heating equipment and the extensive use of low flow fixtures (applied to showerheads and lavatory faucets). An alternate High Efficiency Water Heating provides 1.5 credits for instant gas, electric heat pump or solar water heating. Instant gas water heater already account for 35 percent of the gas water heating market and are expected to be a frequently chosen option. Heat pump water heaters are a technology expected to have a major increase in market adoption in the next 2-3 years.[4] Because of current cost solar water heaters will not be frequently used for code compliance.

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[2] Mark Frankel, Dave Baylon, Mike Lubliner, Residential Energy Conservation Evaluation: Cost Effectiveness of Energy Conservation Measures in New Residential Construction in Washington State, Ecotope, 1995

[3] Ryan Kerr, Building America Kentlake Highlands (Kent, WA) Quadrant Homes Study, BIRA, 2008.

[4] Heat pump water heaters are a major component of the Northwest Power and Conservation Council 6th Power Plan. This will result in a substantial increase in the use of this technology throughout the Northwest in the next few years.

- **Option 8 Renewable Electric Energy:** Applicants could obtain .05 to 3 credits for solar electric or wind generating systems. These are high priced systems but because of existing federal tax credits, state production credits and net metering rules they may be effective good option for some individuals.

09-141 – Residential Building Envelope [Table 6-1]

Building insulation and window requirements advanced for homes in Climate Zone 1 were tightened slightly and were reduced for homes in Climate Zone 2. This code change applies to all homes.

There were numerous residential building envelope proposals submitted to the energy code TAG. Some proposals or parts of proposals were very controversial. These were addressed by the TAG and the current TAG recommendations will work when adopted in conjunction with the adoption of the Chapter 9 provisions. But because the Climate Zone 2 building envelope was reduced in stringency, both 09-140 (chapter 9) and 09-141 (Residential Building Envelope) need to move forward together.

The original intent of the Commerce proposal was to adopt the 2006 WSEC Climate Zone 2 building envelope standards as a single state wide building envelope standard. But a strong desire by the building industry to limit the minimum glazing U-factor in Climate Zone 1 to U-0.32 resulted in modified the requirements for both climate zones.

The first two tables below provide the most utilized prescriptive options for each climate zone from the 2006 WSEC. While the code provides numerous options for compliance, single family construction has been almost exclusively constructed using these options. The last table is the most likely building envelope option proposed for 2009. As we see the principle change here is the reduction of the allowed glazing area from unlimited to 25% of floor area. Very few homes have glazing area exceeding 25% of floor area, making this a near universal standard for all homes.

2006 WSEC Climate Zone 1

Option	Glazing Area % of Floor	Glazing U-Factor Vertical	Glazing U-Factor Overhead	Door U-Factor	Ceiling	Vaulted Ceiling	Wall Above Grade	Wall int Below Grade	Wall ext Below Grade	Floor	Slab on Grade
IV	unlimited	0.35	0.58	0.20	R-38	R-30	R-21	R-21	R-10	R-30	R-10

2006 WSEC Climate Zone 2

Option	Glazing Area % of Floor	Glazing U-Factor Vertical	Glazing U-Factor Overhead	Door U-Factor	Ceiling	Vaulted Ceiling	Wall Above Grade	Wall int Below Grade	Wall ext Below Grade	Floor	Slab on Grade
VI.	unlimited	0.30	0.58	0.20	R-38 adv or R-49	R-38	R-21 int	R-21	R-12	R-30	R-10

Proposed for 2009, Climate Zone 1 and 2.

Option	Glazing Area % of Floor	Glazing U-Factor Vertical	Glazing U-Factor Overhead	Door U-Factor	Ceiling	Vaulted Ceiling	Wall Above Grade	Wall int Below Grade	Wall ext Below Grade	Floor	Slab on Grade
II.*	25%	0.32	0.50	0.20	R-38 adv or R-49	R-38	R-21 Int	R-21 TB	R-10	R-30	R-10 2’

09-080 – Heat Pump Controls: [Section 503.3.8.5] This proposal requires all heat pumps controls to include an outdoor thermostat that locks out electric resistance heating elements when it is warm enough outside for the heat pump to provide all the space heat to the home. This improves the overall performance of the heat pump.

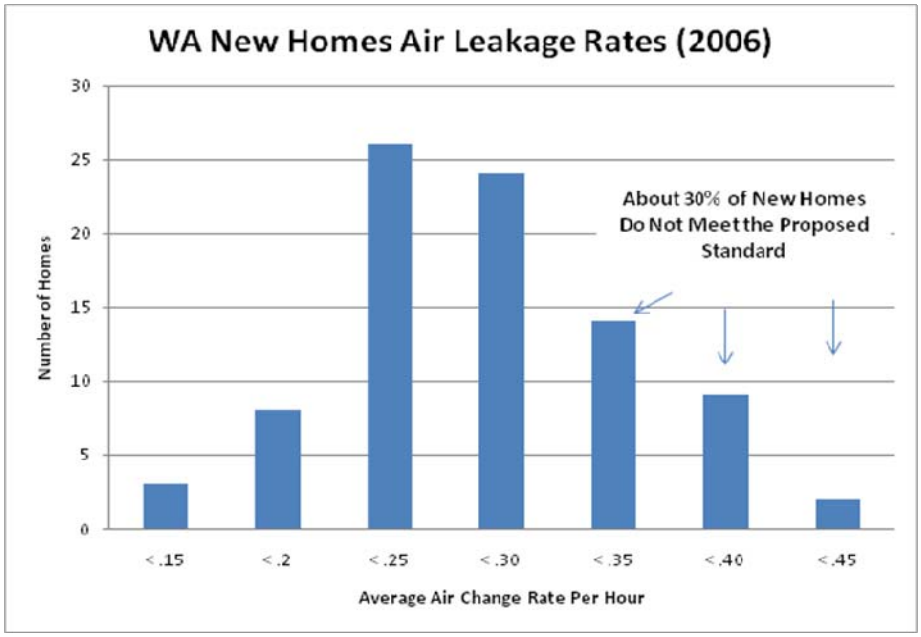
This measure solves a well documented heat pump problem at a very low cost. Most heat pump thermostats are already equipped with this capability, and only require the installer to hook them up and program the system. [5]

09-134 - Building Air Leakage Testing: [Section 502.4.5] This proposal requires all homes to meet a minimum air leakage standard. A blower door test is required to confirm that the home meets the standard. The required sealing standard is 0.00030 Specific Leakage Area. This is equivalent to an average natural air change rate of about 30% per hour.

This may be the most cost effective measure in the package. Air leakage control is already a code requirement and meeting this standard presents no additional cost for materials or labor. It does require the feedback provided by the test equipment. The majority of homes already meet this air leakage standard. However there are still a large number of homes that do not. Testing will bring all homes in compliance with the minimum standard. It is the intent of the proposal that the test be supplied by the builder to the building official.

[5] PCTS, Auxiliary Heat Controls and Thermostats
http://www.ptcsnw.com/downloads/Notes%20on%20Auxiliary%20Heat%20Controls%20and%

Figure 1 WA Air Leakage Rates



Base on the study by RLW Analytics, SINGLE-FAMILY RESIDENTIAL NEW CONSTRUCTION CHARACTERISTICS AND PRACTICES STUDY, Northwest Energy Efficiency Alliance, 2007.

The development of a building performance testing industry needed to accomplish this work has been under way in our state for a number of years. This includes the EnergyStar home programs, duct performance testing programs, and state and utility weatherization programs. This will be greatly expanded in the coming year by utility programs[6] and federal recovery act projects[7]. Additional training in this area is funded by DOE grants to the WSU Energy Program through 2010.

09-135 – HVAC Fan Power Limits: [Section 503.4.1] This proposal requires all furnaces and heat pumps to include a direct induction fan motor. This is variable speed DC motor that only uses 30 to 50 percent of the energy of a standard split capacitor motors. If we used this technology exclusively to provide space heating there would be a reduction in energy use roughly equivalent to a standard size refrigerator. When the fan is also used for cooling, whole house ventilation or as a circulation fan, the reduction in energy use will be greater.

09-139 – Residential Lighting [Section 505.1] The 2006 WSEC requires all outdoor lighting to include high efficiency light bulbs with a pin base. This proposal will require that 50 percent of all permanently installed lamp sockets to include a high efficiency lamps. The requirements for a pin based socket have been removed, allowing any socket type to be used. This proposal is consistent with language adopted into the 2009 IECC and IRC.

[6] Initiative 937 requirements for electric utilities to obtain all cost effective conservation will lead to additional development of the weatherization and the building performance testing industry.

[7] Federal Recovery Act will be providing millions in funding to weatherization projects in our state. Building performance testing training is a component of these programs.

It is expected that this rule will result in the increased use of screw base compact fluorescent lamps, tube fluorescent lamps or in some cases led lamps. This proposal will primarily result in a change in the builder selection of fixture design. Fixtures will be chosen that look good when used with a fluorescent lamp. This measure is designed to reduce the lighting power of the home by about 35%.

Cost Analysis

For most measures, the cost analysis for this code proposal is based on large regional data sets or cost analysis conducted in as part of national standards development. This provides a high level credibility to the estimates. The estimated measure cost and data source is listed in Table A-1 in the appendix. The primary cost references are described in the following paragraphs.

NPCC Sixth Power Plan Support Documentation is developed by Northwest Power and Conservation Council Staff and approved by the Regional Technical Forum (RTF), a panel of energy conservation implementation experts. It is an important source of information for all regional power planning activities. The council has been collecting resource cost data since 1983. These data sets are updated every 5 years to support the development of the regional power plan. The Sixth Power Plan draft was released for review in Sept 2009. The current data includes thousands of data points for residential building envelope, HVAC equipment and lighting that was provided to the council by utilities providing financial support to residential new construction projects as well as weatherization programs.

US DOE Standards Technical Support Document for Furnaces and Boilers, Sept 2007 provides cost for improved furnaces. This document provides detailed record of the federal public process documents the cost of equipment. The resulting cost estimates are the full retail cost of the equipment, venting and installation to the consumer. We have modified these estimates to reflect a wholesale price consistent with the markups.

For water heating measures, we used the ACEEE Consumer Guide to Home Energy Savings. November 2007 as our referenced cost source. ACEEE has been producing this document for more than 20 years and is currently in the 9th edition. We also checked internet pricing to confirm these cost estimates.

Additional sources are referenced including internet pricing and British Columbia Hydro. We also reference several regional and national building performance studies in the table. We use this type of cross referencing to provide confidence in the sources we have quoted.

Builder **mark up and taxes** are added to the cost in the consumer cash flow analysis that follows. We have added **37%** to the base cost in all cases.

Table 1 shows the estimated costs calculated for several example homes. The cost details of each measure and each building are included in Appendix A. These homes were selected to show the range of cost and savings anticipated by the energy code proposal. The table is based on a set of construction paths that were designed to represent the options that are most likely to be selected by builders. The

most likely scenario is typically the lowest cost set of measure, with consideration for the difficulty of implementing the measures. These measures are selected from prescriptive WSEC table (6-1) and the options table (WSEC 9-1). Using the measure cost estimates in a set of least cost measures that would meet the requirements were generated for each example home. The results of this analysis suggested that the cost of code compliance under this code would be between $.89 and $1.47 per square foot of home for the smaller homes. For most home buyers, about 75% of new homes, the incremental cost will be represented by the 2200 SF gas heated home.

Table 1 Energy Code Proposal, Compliance Costs

House size	**Heating System**	**Incremental Cost**	
		Zone 1	$/ SF
2200 SF 1.5 story, crawlspace	Gas Furnace	$2,717	$1.23
	Heat Pump	$3,192	$1.45
1350 SF, Crawlspace	Gas Furnace	$1,865	$1.38
	Heat Pump	$1,989	$1.47
	Zonal (electric)	$1,611	$1.19
5001 SF, 2 stories, Basement	Gas Furnace	$5,538	$1.11
	Heat Pump	$5,661	$1.13
		Zone 2	$/ SF
2200 SF 1.5 story, crawlspace	Gas Furnace	$2,180	$0.99
	Heat Pump	$2,532	$1.15
1350 SF, Crawlspace	Gas Furnace	$1,458	$1.08
	Heat Pump	$1,582	$1.17
	Zonal (electric)	$1,204	$0.89
5001 SF, 2 stories, Basement	Gas Furnace	$5,036	$1.01
	Heat Pump	$5,159	$1.03

Energy Savings Benefits

The energy savings analysis conducted for the final Tag proposal was conducted using the same analysis done for the original Department of Commerce proposal but adjusted to include only the final package of measures in the TAG process. Table 2 summarizes the energy savings for the same example homes used in Table 2. The table compares the Seattle climate and the Spokane climate. In general many of the code changes are more cost effective in Spokane because of the colder climate.

These savings were generated using the same prototypes and evaluating them with a thermal simulation to estimate the energy impacts of the new provisions of the code on energy use of these selected house types. The analysis was done for both Seattle and Spokane.

The overall savings impacts were compared to an identical home designed to meet the current 2006 WSEC with the current level of efficiency required for the domestic hot water (DHW) load and current

practice estimates for lighting, appliances and other. The code does address improved efficiency in both the DHW and the lighting technologies applied in the residential sector. Savings fractions were calculated from the total energy use in the home including DHW, lighting, appliances, and miscellaneous loads.

In the final code proposal the savings fractions varied with the individual home type and fuel type. Table 3 shows the percentage savings (from the total home energy use) in the final code proposal as passed by the Energy TAG.

Table 2 Energy Code Proposal, Energy Savings

House size	Heating System	Savings from 2006 WSEC	
		kWh	Therms
Seattle			
2200 SF 1.5 story, crawlspace	Gas Furnace	1713	217
	Heat Pump	5157	0
1350 SF, Crawlspace	Gas Furnace	1221	72
	Heat Pump	2363	0
	Zonal (electric)	1499	0
5001 SF, 2 stories, Basement	Gas Furnace	3072	223
	Heat Pump	5086	0
Spokane			
2200 SF 1.5 story, crawlspace	Gas Furnace	1733	312
	Heat Pump	7474	0
1350 SF, Crawlspace	Gas Furnace	1279	103
	Heat Pump	3646	0
	Zonal (electric)	1554	0
5001 SF, 2 stories, Basement	Gas Furnace	3018	258
	Heat Pump	6557	0

Table 3 Energy Savings 2009 WSEC Proposal

House size	Heating System	Savings (2006 WSEC)	
		Seattle	Spokane
		%	%
2200 SF 1.5 story, crawlspace	Gas Furnace	26	27
	Heat Pump	25	31
1350 SF, Crawlspace	Gas Furnace	17	18
	Heat Pump	17	20
	Zonal (electric)	16	13
5001 SF, 2 stories, Basement	Gas Furnace	22	20
	Heat Pump	24	23

Cash Flow Analysis

For the consumer the cost of ownership needs to consider both first cost and life cycle cost. To demonstrate the balance between these two factors a consumer cash flow analysis has been developed. The analysis is based on current (2009) economic conditions. This includes a standard down payment of 20% and recent reductions in the price of natural gas. We have kept the cost of mortgage at 6%, predicting that the 2009 rates of 5 to 5 1/2 % are not likely to last. Also Included in the analysis is the tax deduction taken for interest payments on the home owner's mortgage. In 2008 the IRS tax rate for married filing jointly with net incomes of $50,000 is 18 percent.

Key Inputs

- Down Payment: 20 percent
- Mortgage Rates: 6 percent.
- Interest Tax Deduction: 18 percent
- Base Electric Rate: $0.0741 kWh (2009)
- Base Gas Rate: $1.21Therm (2009)

The 2009 gas and electric rates are population weighted average price to Washington State customers. Future cost is the 2009 prices multiplied by the Energy Administrations estimate of price changes (March 2009). This is an inflation adjusted energy price index. It allows analysis to be conducted using present value of money without making additional adjustments for inflation. You will note that the projected gas prices actually go down in the next few years, and then slowly increase over time. This adjustment is made to account for surplus production capacity in fuel because of the current economic conditions. The results of this analysis are illustrated in Graph A-1, Fuel Price Estimate is included in Appendix A.

The fuel cost used here does not include local or state utility taxes or franchise fees. The fuel price increase noted here also do not include the price effects that may result from proposed climate mitigation regulations, proposed environmental regulations for natural gas exploration (fracking) or the implementation of the state's renewable portfolio standard. The energy efficiency measures proposed

here will reduce the risk to consumers of future increases in energy prices that may result from these regulations.

A basic description of the cash flow analysis is this. First it considers the down payment required when the home is purchased. In all our examples we use a 20 percent down payment. This puts the home owner in a negative cash flow position. In future years, the consumer cost is the additional mortgage payments related to the energy efficiency measures, both principal and interest. Savings include the reduced energy cost and the income tax deduction for the home mortgage.

Each year the resulting cash flow position of the home owner is represented as the difference between the cumulative cost and cumulative savings. At the end of the first winter, the consumer will begin to benefit from a reduced cost of ownership. Positive cash flow varies from project to project. But the majority of home buyers will be in a positive cash flow position by the end of the third year of ownership. The down payment will be fully recaptured by this time. Savings will increase as energy cost increase – while the cost of the mortgage will remain the same over time. Figure 2 Example Cash Flow provides an example of the cash flow for a 2200 SF gas heated home located in Seattle. Additional graphs for the other prototypes are included in Appendix A. The simplified cash flow summary for all prototypes is represented in Table 4.

Figure 2 Example Cash Flow

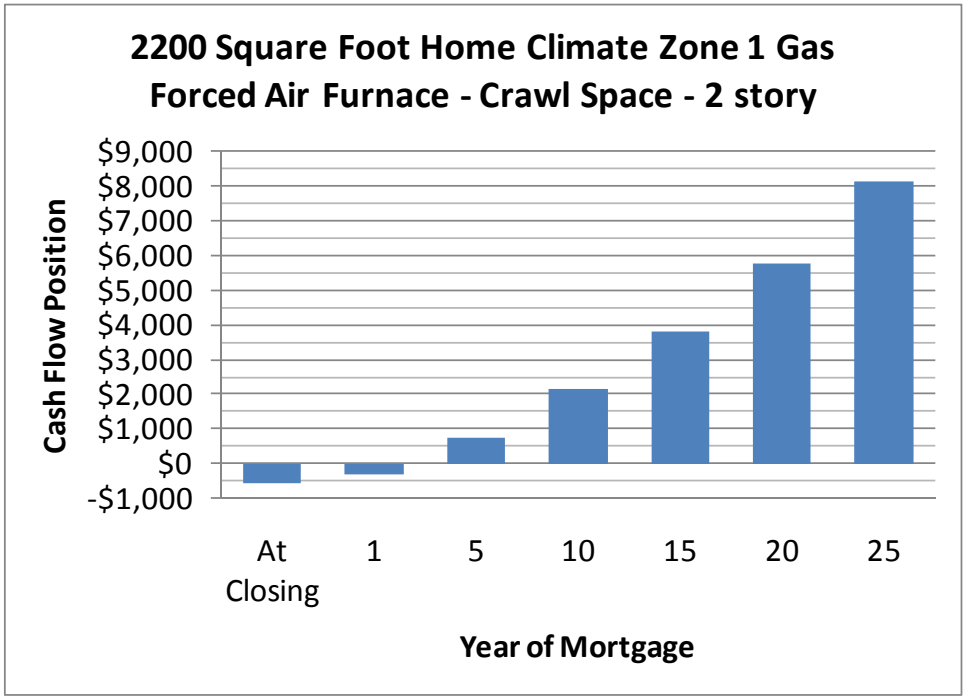


Table 4 Consumer Cash Flow Summary

House size	Heating System	Home Owner Cash Flow		
Climate Zone 1		**Year of home ownership**		
		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	$ 722	$ 2,125	$ 3,827
	Heat Pump	$ 351	$ 1,496	$ 2,903
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Climate Zone 2		**Year of home ownership**		
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2200 SF 2 story, crawlspace	Gas Furnace	$ 1,520	$ 3,653	$ 6,178
	Heat Pump	$ 1,849	$ 4,570	$ 7,704
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	Heat Pump	$ 750	$ 1,948	$ 3,364
	Zonal (electric)	$ 82	$ 459	$ 927
5001 SF, 2 stories, Basement	Gas Furnace	$ 441	$ 2,084	$ 6,538
	Heat Pump	$ 310	$ 1,882	$ 3,836

Appendix A – Detailed Cash Flow Analysis

Graph A-1 Fuel Price Estimate

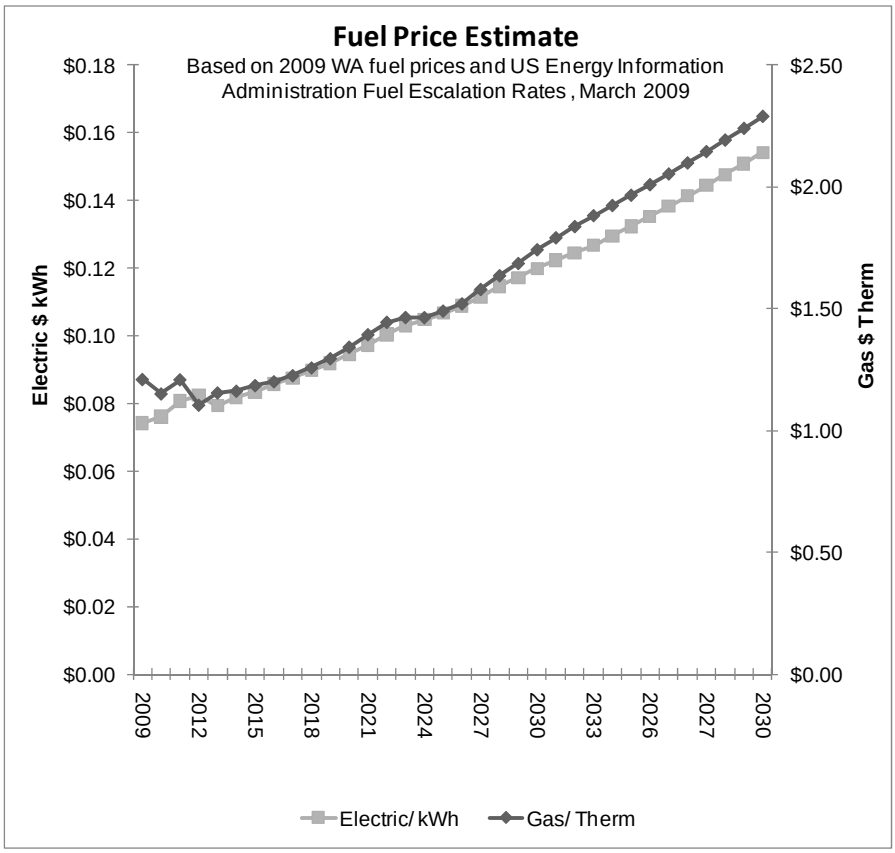


Table A-1 Measure Cost

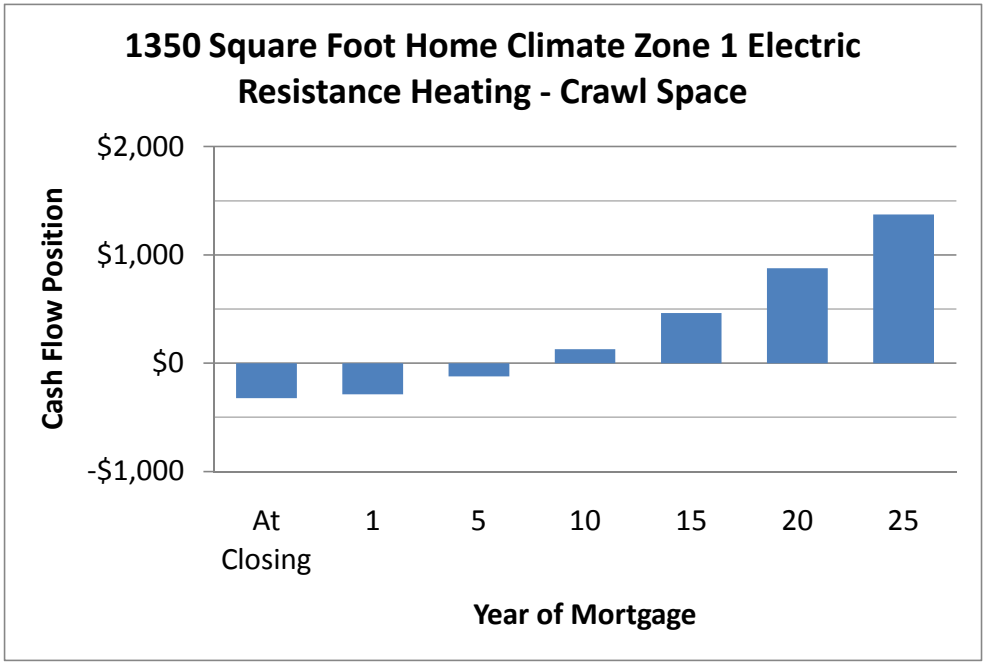
Measure	Cost	Data Sources
Envelope	$/ft2 or Unit	
Window		
U- 0.32	$0.00	U-0.32 windows are currently available as the lowest cost code compliance window package.
U- 0.28	$0.90	NPCC Sixth Power Plan, Support documentation
Ceiling		
R-49 Standard	$0.22	NPCC Sixth Power Plan, Support documentation
Floor		
R-38	$0.27	NPCC Sixth Power Plan, Support documentation
Air Sealing	$ / item	
Blower Door Testing	$200.00	NPCC Sixth Power Plan, Support documentation
HVAC System	$ / item	
Duct Sealing	$350.00	NPCC Sixth Power Plan, Support documentation This measure is already adopted into the code. But it has been included as a cost for the 2010 analysis.
Interior Duct Placement	$300.00	NPCC Sixth Power Plan, Support documentation Interior duct placement cost $650. But duct testing is not required when all ducts are inside the heated space, resulting in an incremental cost of $300. Builders have noted that there is no incremental cost in several interviews, including Mark Frankel, Dave Baylon, Mike Lubliner, Residential Energy Conservation Evaluation: Cost Effectiveness of Energy Conservation Measures in New Residential Construction in Washington State, Ecotope, 1995 Ryan Kerr, Building America Kentlake Highlands (Kent, WA) Quadrant Homes Study, BIRA, 2008.
90+ AFUE Furnace	$505.00	US DOE Standards Technical Support Document for Furnaces and Boilers, Sept 2007. Retail installed cost for replacement $693, less 1.37 markup $506. Lower cost have been noted, web store, same brand same store incremental cost for a Goodman Furnace $172.
8.5 HSPF Heat Pump	$742.00	NPCC Sixth Power Plan, Support documentation
High Efficiency Fan Motor (ECM)	$180.00	US DOE Standards Technical Support Document for Furnaces and Boilers, Sept 2007. This document shows a full retail cost of $240. We adjusted the cost to reflect a wholesale price.
Domestic Hot Water	$ / item	
Electric Tank 0.93+ EF	$70.00	ACEEE Consumer Guide to Home Energy Savings. November 2007.
Gas Tank 0.62+ EF	$175.00	ACEEE Consumer Guide to Home Energy Savings. November 2007.
Tankless Gas 0.82+ EF	$500.00	BC Hydro has $700, ACEEE has $750 incremental, Internet pricing is as low as $580 heater + 210 for a venting kit. It is worth noting that sealed vent instant water heater cost less than sealed vent tank water heaters required for interior spaces.
Heat Pump Water Heater	$852.00	NPCC Sixth Power Plan, Support documentation
Low Flow Fixtures	$32.00	NPCC Sixth Power Plan, Support documentation
Lighting	$ / item	
CFL Lamp	$1.50	Current lamp costs for various CFL bulbs. The final cost per home is based

1350 Square Foot Home Climate Zone 1
Electric Resistance Heating - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Window	U 0.35	See Chaper 9	$ -	0
Attic	R-38	R-49	$ 0.22	$ 297
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Lighting - 50% High Efficiency Lamps			$ 1.50	$ 34
Chapter 9 (1 credit required for small home)				
Option 3a Building Envelope 0.5 Credits				
Windows	U - 0.35	U- 0.028	$ 0.90	$ 180
Floor	R-30	R-38	$ 0.27	$ 363
Option 5a Water Heating 0.5 Credits				
.93 EF Water Heater & Low Flow fixture	.90 EF	.93 EF		$ 102
Sub Total				$ 1,176
Overhead + taxes				1.37
Total				$ 1,611

Cost per Square Foot				$ 1.19

Energy Savings		
	Therms	
	kWh	1499



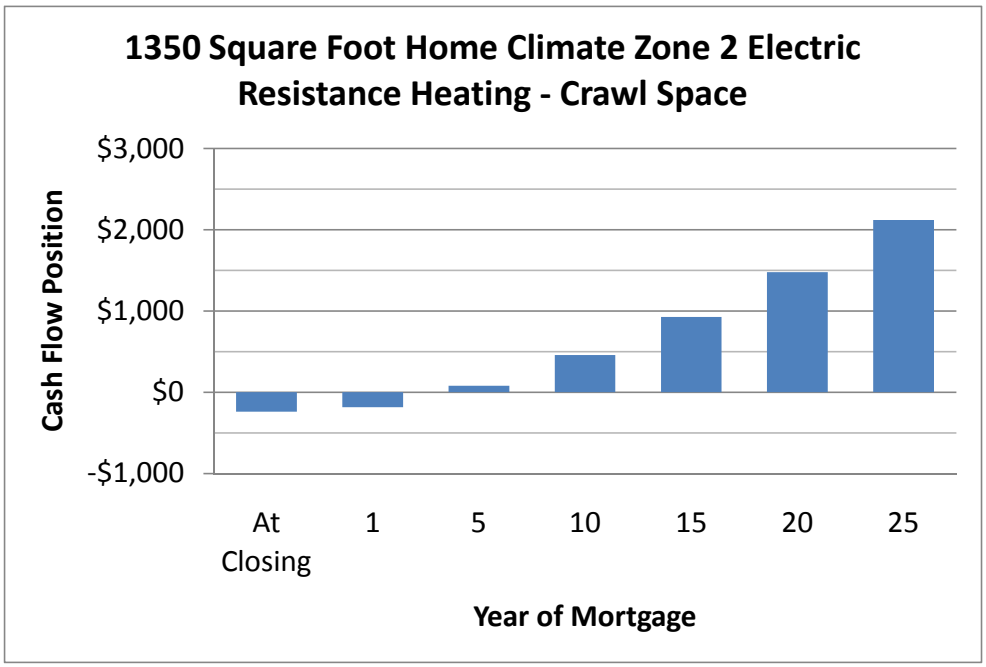
Small electric resistance heated homes represent about 3% of WA new housing stock

1350 Square Foot Home Climate Zone 2
Electric Resistance Heating - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Window	U 0.30	U 0.32	$ -	-
Attic	R-49	R-49	$ -	$ -
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Lighting - 50% High Efficiency Lamps			$ 1.50	$ 34
Chapter 9 (1 credit required for small home)				
Option 3a Building Envelope 0.5 Credits				
Windows	U - 0.35	U- 0.028	$ 0.90	$ 180
Floor	R-30	R-38	$ 0.27	$ 363
Option 5a Water Heating 0.5 Credits				
.93 EF Water Heater & Low Flow fixture	.90 EF	.93 EF		$ 102
Sub Total				$ 879
Overhead + taxes				1.37
Total				$ 1,204

Cost per Square Foot				$ 0.89

Energy Savings		
	Therms	
	kWh	1554



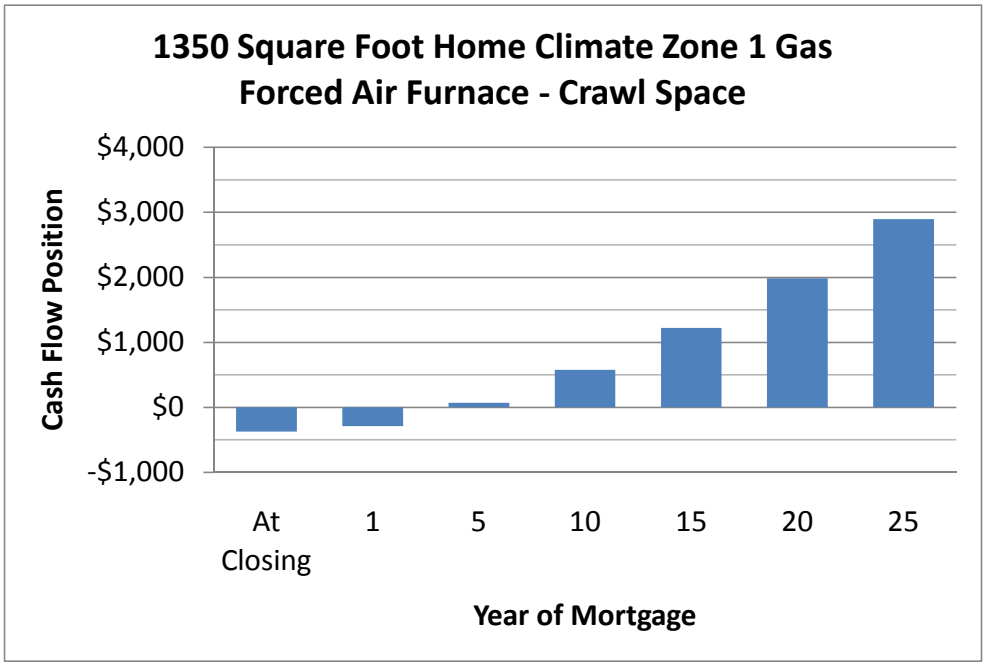
Small electric resistance heated homes represent about 3% of WA new housing stock

1350 Square Foot Home Climate Zone 1
Gas Forced Air Furnace - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	$ -
Attic	R-38	R-49	$ 0.22	$ 297
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 34
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing (passed 2008)	NR	6% Max	$ 350.00	$ 350
Chapter 9 (1 credit required for small home)				
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,361
Overhead + taxes				1.37
Total				$ 1,865

Cost per Square Foot				$ 1.38

Energy Savings		
	Therms	72
	kWh	1221



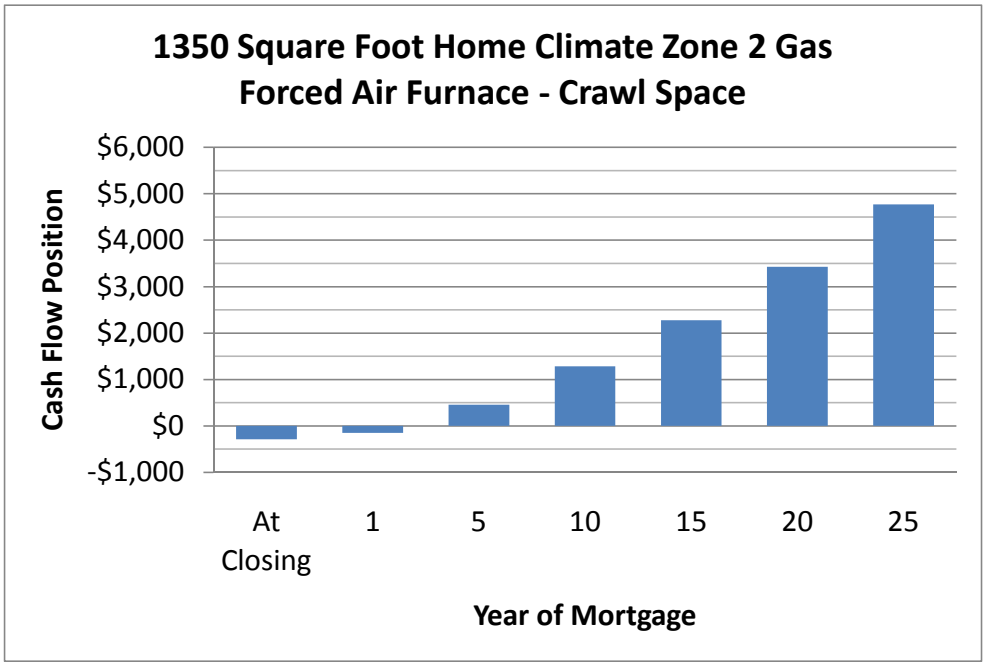
Small gas heated homes represent about 2% of WA new housing stock

1350 Square Foot Home Climate Zone 2
Gas Forced Air Furnace - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U-0.30	U- 0.032	$ -	No change
Attic	R-49	R-49		No change
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 34
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing (passed 2008)	NR	6% Max	$ 350.00	$ 350
Chapter 9 (1 credit required for small home)				
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,064
Overhead + taxes				1.37
Total				$ 1,458

Cost per Square Foot				$ 1.08

Energy Savings		
	Therms	103
	kWh	1279

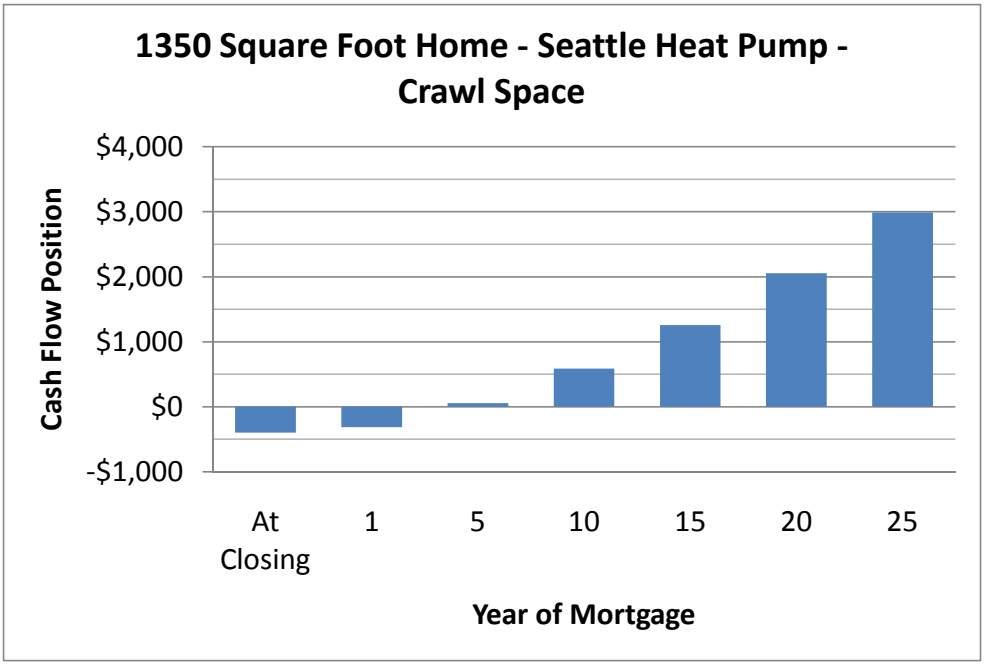


Small gas heated homes represent about 2% of WA new housing stock

1350 Square Foot Home - Seattle
Heat Pump - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	No change
Attic	R-38	R-49	$ 0.22	$ 297
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 35
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (Base Case, Not required CH 9 Option 2)	NR	6% Max	$ 350.00	$ 350
Heat Pump Lock Out				$ 90
Chapter 9 (1 credit required for small home)				
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,452
Overhead + taxes				1.37
Total				$ 1,989
Cost per Square Foot				$ 1.48

Energy Savings		Units
	Therms	
	kWh	2363

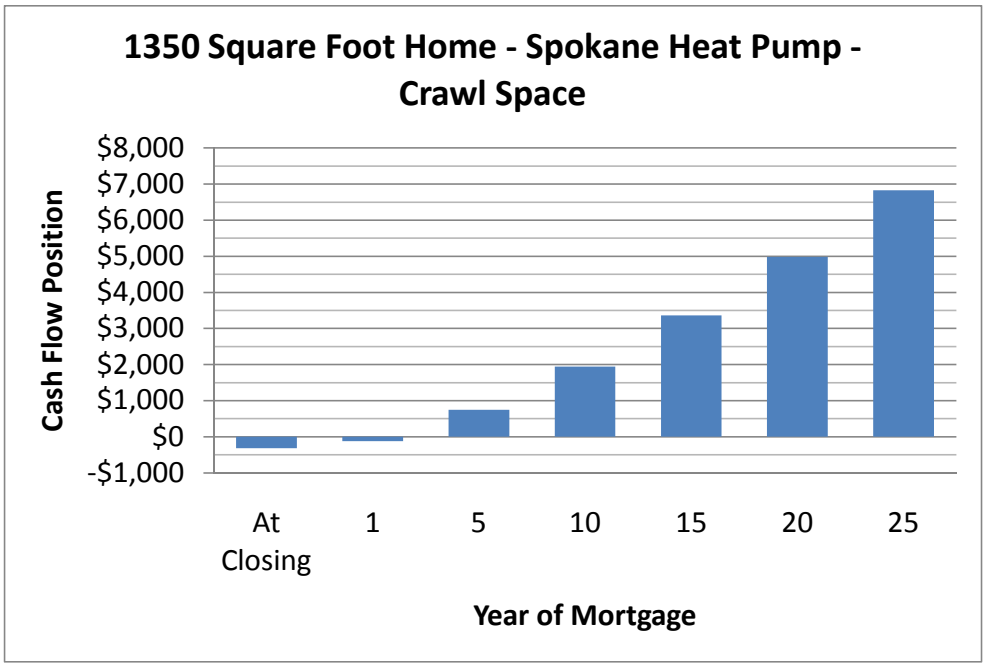


Small heat pump homes represent less than 1% of WA new housing stock

1350 Square Foot Home - Spokane
Heat Pump - Crawl Space
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	No change
Attic	R-49	R-49		
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 35
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (Base Case, Not required CH 9 Option 2)	NR	6% Max	$ 350.00	$ 350
Heat Pump Lock Out				$ 90
Chapter 9 (1 credit required for small home)				
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,155
Overhead + taxes				1.37
Total				$ 1,582
Cost per Square Foot				$ 1.18

Energy Savings		Units
	Therms	
	kWh	3646



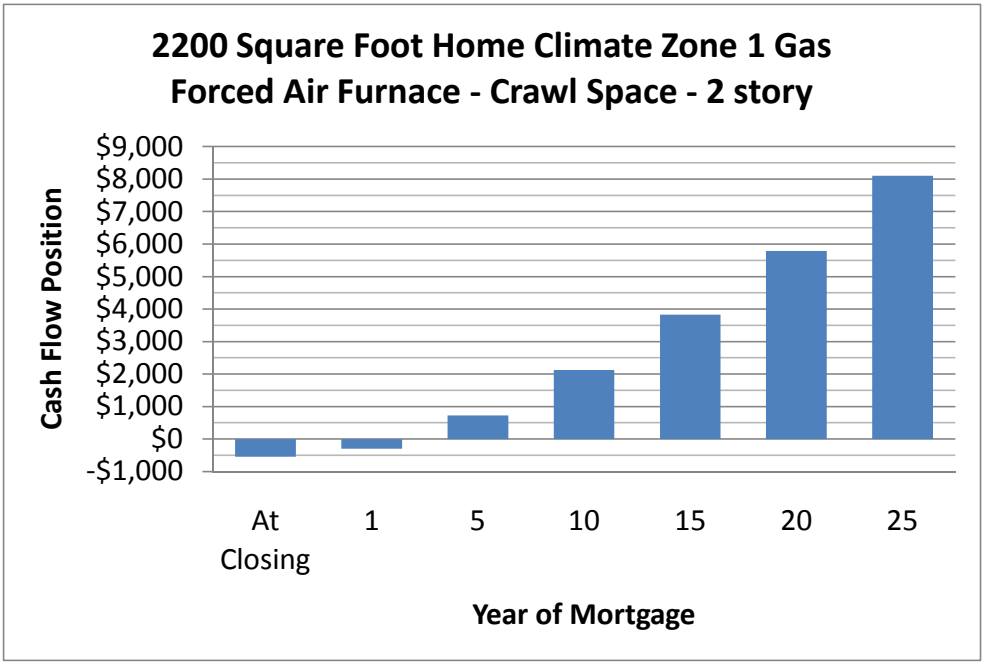
Small heat pump homes represent less than 1% of WA new housing stock

2200 Square Foot Home Climate Zone 1
Gas Forced Air Furnace - Crawl Space - 2 story
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	$ -
Attic	R-38	R-49	$ 0.22	$ 392
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 56
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (Base Cost. Not required CH 9 Option 2)		6% Max	$ 350.00	$ 350
Chapter 9 (2 credits required)				
Option 1a, High Efficiency Equpment	80 % AFUE	92% AFUE	$ 505.00	$ 505
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,983
Overhead + taxes				1.37
Total				$ 2,717

Cost per Square Foot				$ 1.23

Energy Savings		
	Therms	217
	kWh	1713



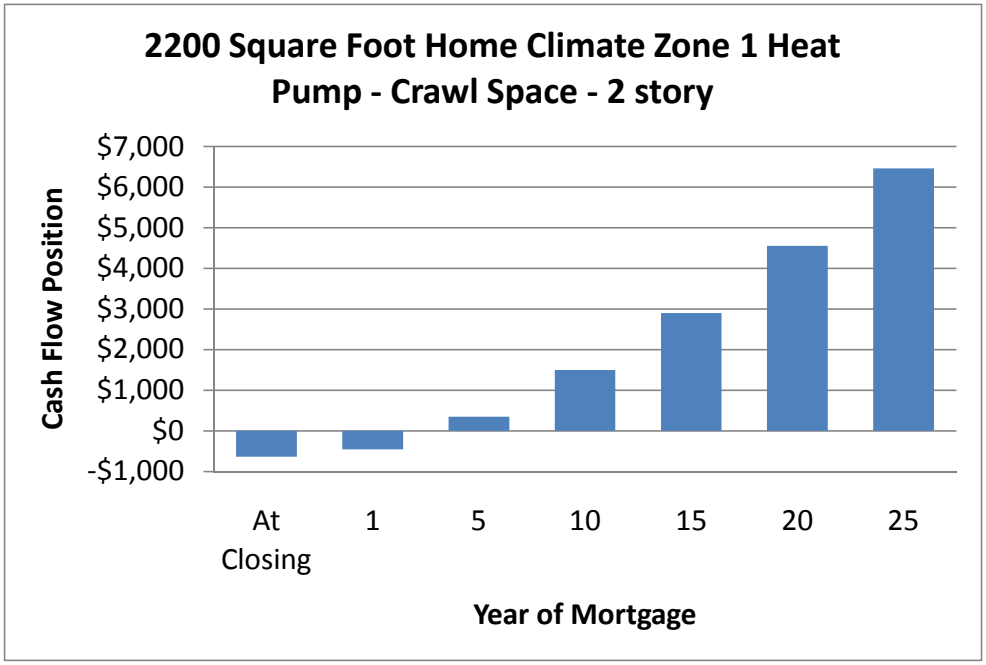
Medium size gas heated homes represent about 74% of new WA homes.

2200 Square Foot Home Climate Zone 1
Heat Pump - Crawl Space - 2 story
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032		No change
Attic	R-38	R-49	$ 0.22	$ 392
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 56
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max	$ 350.00	$ 350
Heat Pump Lock Out				$ 90
Chapter 9 (2 credits required)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	$ 762.00	$ 762
Option 2, Ducts inside Heated Space			$ 300.00	$ 300
Sub Total				$ 2,330
Overhead + taxes				1.37
Total				$ 3,192

Cost per Square Foot				$ 1.45

Energy Savings		
	Therms	0
	kWh	4453



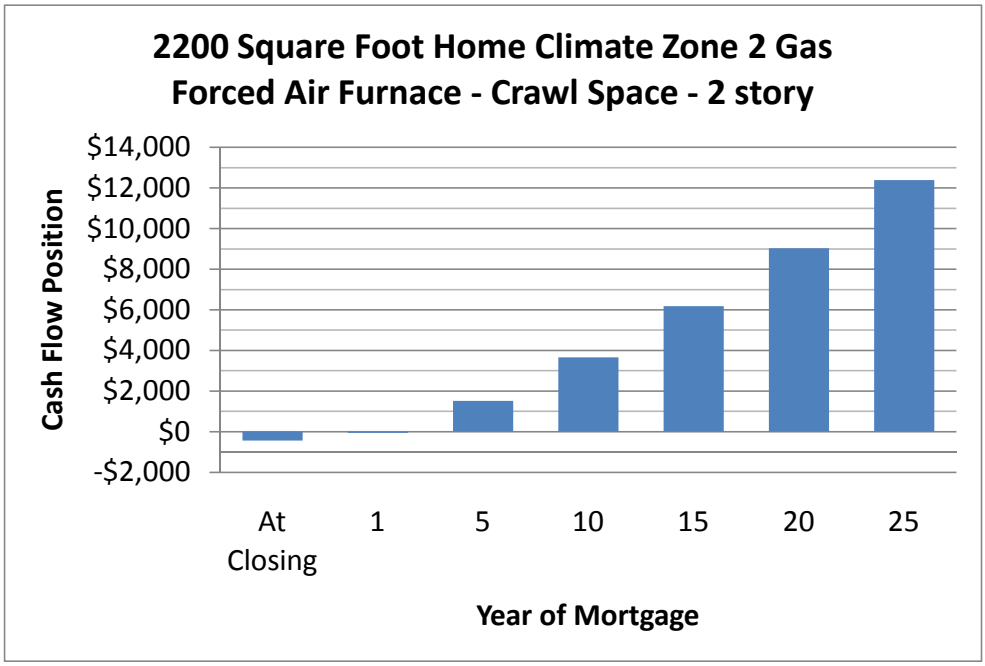
Medium size heat pump homes represent about 8% of WA new housing stock

2200 Square Foot Home Climate Zone 2
Gas Forced Air Furnace - Crawl Space - 2 story
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.30	U- 0.032	$ -	$ -
Attic	R-49	R-49	$ -	No chang
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 56
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (Base Cost. Not required CH 9 Option 2)		6% Max	$ 350.00	$ 350
Chapter 9 (2 credits required)				
Option 1a, High Efficiency Equpment	80 % AFUE	92% AFUE	$ 505.00	$ 505
Option 2, Ducts inside Heated Space (incremental over sealed ducts)			$ 300.00	$ 300
Sub Total				$ 1,591
Overhead + taxes				1.37
Total				$ 2,180

Cost per Square Foot				$ 0.99

Energy Savings		
	Therms	312
	kWh	1733



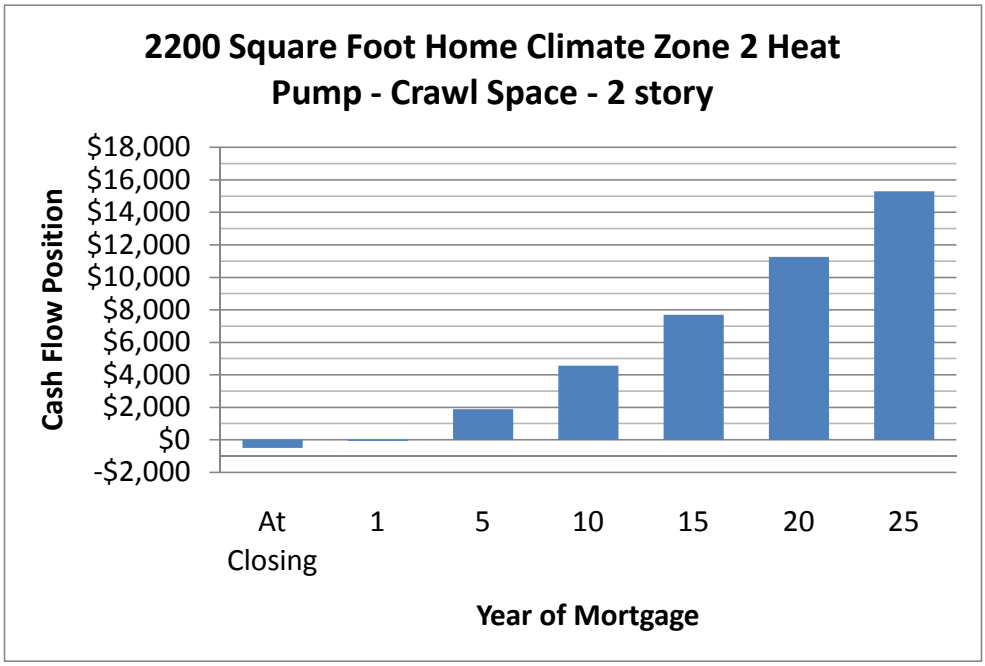
Medium size gas heated homes represent about 74% of new WA homes.

2200 Square Foot Home Climate Zone 2
Heat Pump - Crawl Space - 2 story
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.30	U- 0.032	$ -	No change
Attic	R-49	R-49	$ -	No change
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 56
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max	$ 350.00	$ 350
Chapter 9 (2 credits required)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	$ 762.00	$ 762
Option 2, Ducts inside Heated Space			$ 300.00	$ 300
Sub Total				$ 1,848
Overhead + taxes				1.37
Total				$ 2,532

Cost per Square Foot				$ 1.15

Energy Savings		
	Therms	0
	kWh	7568

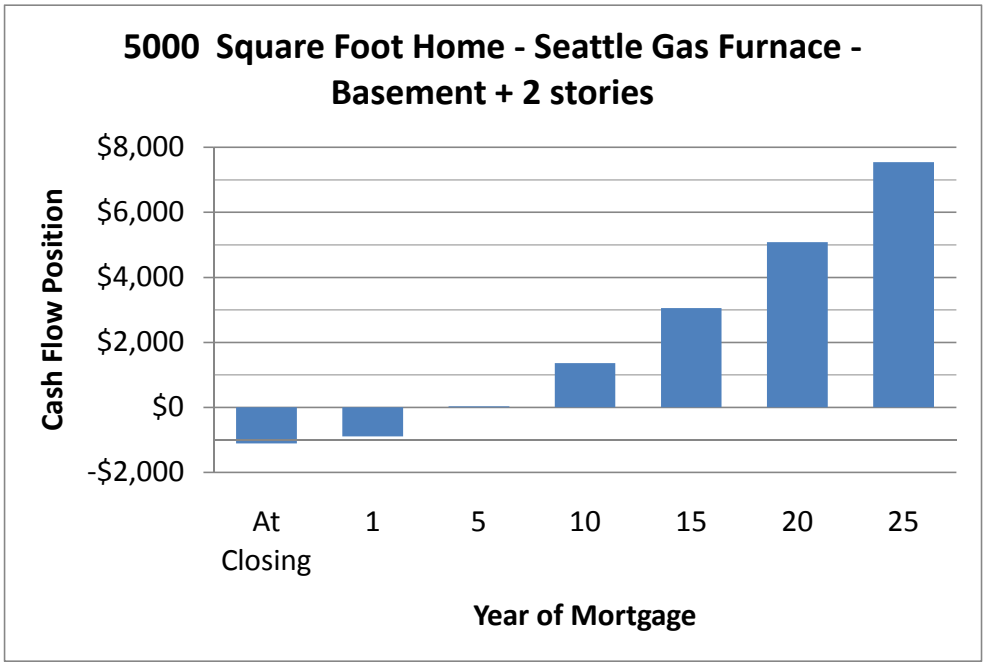


Medium size heat pump homes represent about 8% of WA new housing stock

5000 Square Foot Home - Seattle
Gas Furnace - Basement + 2 stories
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	No change
Attic	R-38	R-49	0.22 SF	$ 366
Slab thermal break	Non TB	TB slab	.09 LF	$ 126
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 128
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Chapter 9 (3 credits required for large home)				
Option 1a, High Efficiency Equipment	.8 AFUE	.92 AFUE	$ 742.00	$ 742
Option 2, Ducts inside Heated Space - No Cost for Basement Homes			$ -	$ -
Option 4 B Air tight home with HRV				$ 2,300
Sub Total				$ 4,042
Sub Total				$ 4,042
Overhead + taxes				1.37
Total				$ 5,538
Cost per Square Foot				$ 1.11

Energy Savings		Units
	Therms	223
	kWh	3072

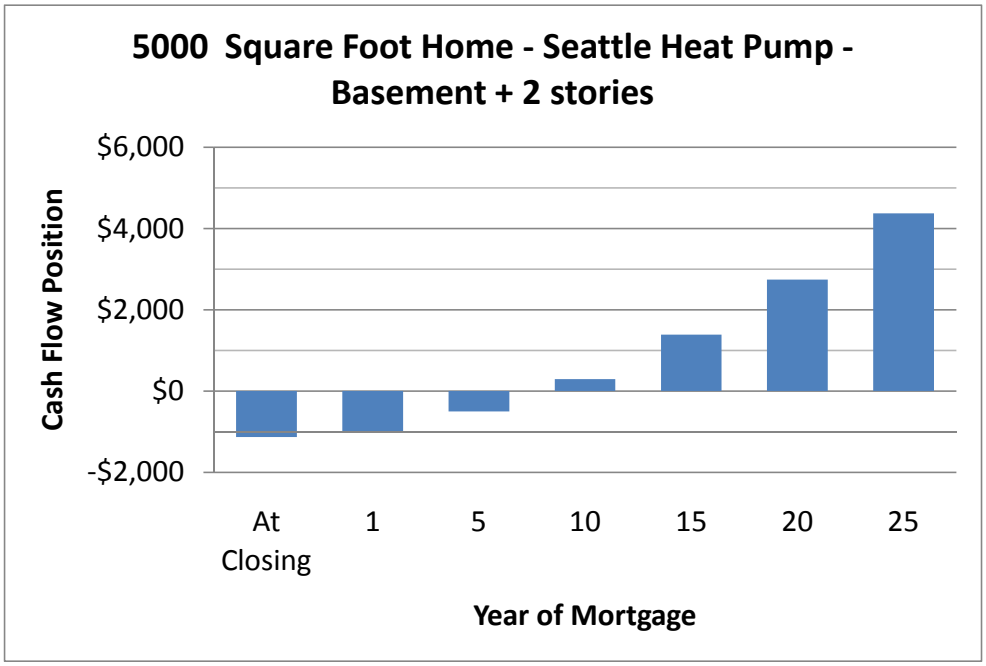


Large gas heated homes represent about 2% of WA new homes

5000 Square Foot Home - Seattle
Heat Pump - Basement + 2 stories
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	$ -	No change
Attic	R-38	R-49	0.22 SF	$ 366
Slab thermal break	Non TB	TB slab	.09 LF	$ 126
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 128
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Heat Pump lock out				$ 90
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Chapter 9 (3 credits required for large home)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	$ 742.00	$ 742
Option 2, Ducts inside Heated Space - No Cost for Basement Homes			$ -	$ -
Option 4 B Air tight home with HRV				$ 2,300
Sub Total				$ 4,132
Overhead + taxes				1.37
Total				$ 5,661
Cost per Square Foot				$ 1.13

Energy Savings		Units
	Therms	
	kWh	5086

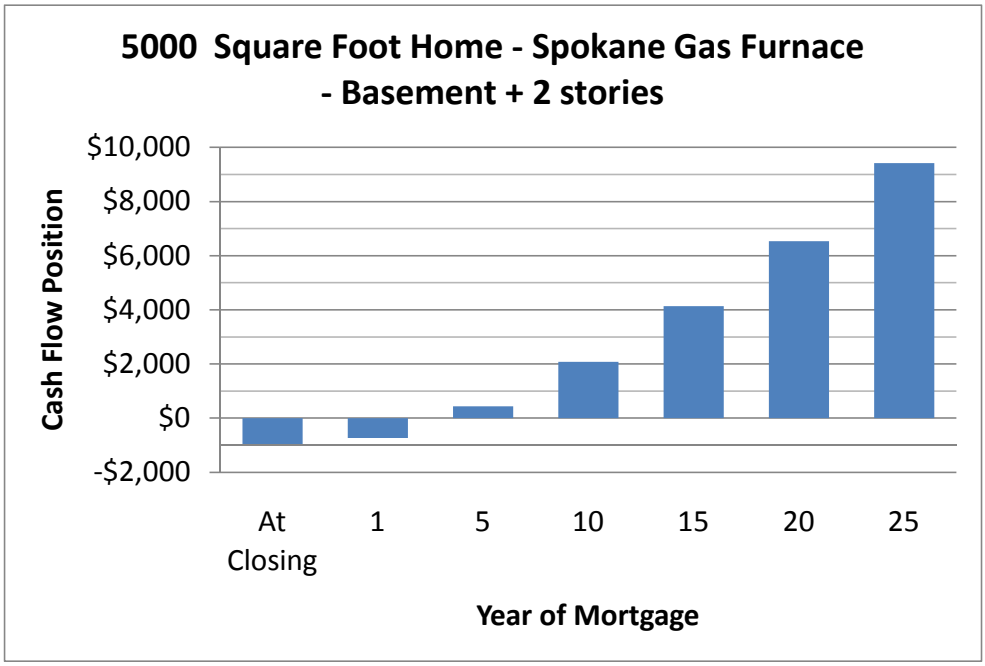


Large heat pump homes represent less than 1% of new WA homes

5000 Square Foot Home - Spokane
Gas Furnace - Basement + 2 stories
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.30	U- 0.032	$ -	No change
Attic	R-49	R-49		No Change
Slab thermal break	Non TB	TB slab	.09 LF	$ 126
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 128
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Chapter 9 (3 credits required for large home)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	$ 742.00	$ 742
Option 2, Ducts inside Heated Space - No Cost for Basement Homes			$ -	$ -
Option 4 B Air tight home with HRV				$ 2,300
Sub Total				$ 3,676
Sub Total				$ 3,676
Overhead + taxes				1.37
Total				$ 5,036
Cost per Square Foot				$ 1.01

Energy Savings		Units
	Therms	258
	kWh	3018

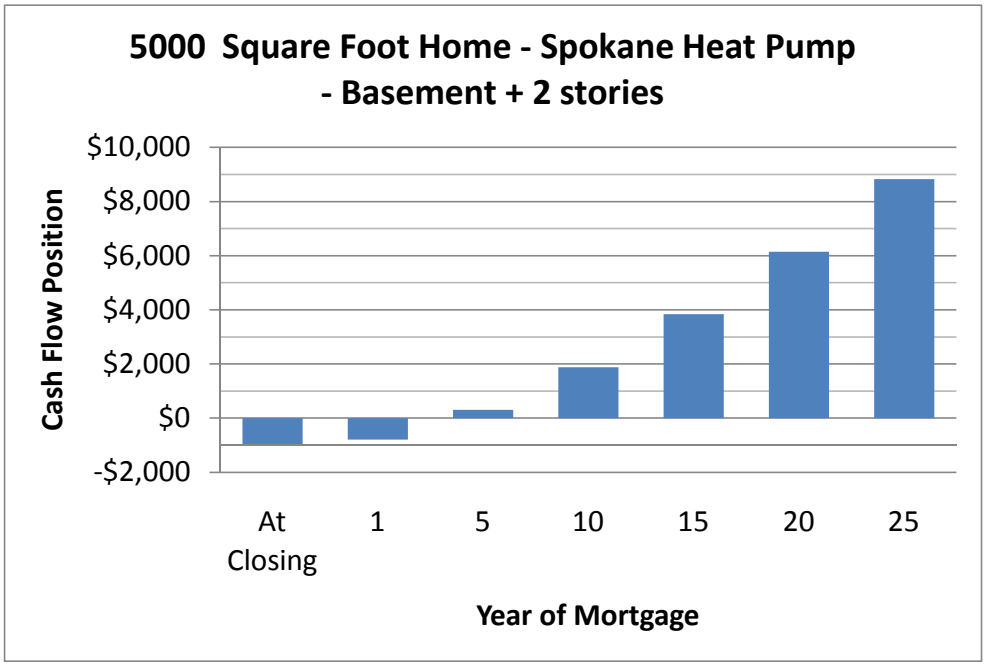


Large gas heated homes represent about 2% of WA new homes

5000 Square Foot Home - Spokane
Heat Pump - Basement + 2 stories
Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.30	U- 0.032	$ -	No change
Attic	R-49	R-49		No Change
Slab thermal break	Non TB	TB slab	.09 LF	$ 126
Infiltration	Prescriptive	Tested	$ 200.00	$ 200
Interior Lighting	NR	50% of lamps	$ 1.50	$ 128
HVAC Motor Efficiency	NR	ECM	$ 180.00	$ 180
Heat Pump lock out				$ 90
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Chapter 9 (3 credits required for large home)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	$ 742.00	$ 742
Option 2, Ducts inside Heated Space - No Cost for Basement Homes			$ -	$ -
Option 4 B Air tight home with HRV				$ 2,300
Sub Total				$ 3,766
Overhead + taxes				1.37
Total				$ 5,159
Cost per Square Foot				$ 1.03

Energy Savings		Units
	Therms	
	kWh	6557



Large heat pump homes represent less than 1% of new WA homes