

2009 Washington State Energy Code: Analysis of Code Changes Adopted By the Washington State Building Code Council

Chuck Murray, Washington State Department of Commerce Energy Policy Division
David Baylon, Ecotope

Executive Summary

This paper provides consumer cash flow analysis of the amendments to the residential sections of the Washington State Energy Code as adopted by the Washington State Building code council in 2009. The reports compare the first cost and energy savings of the 2009 edition of the code when compared to the 2006 edition of code.

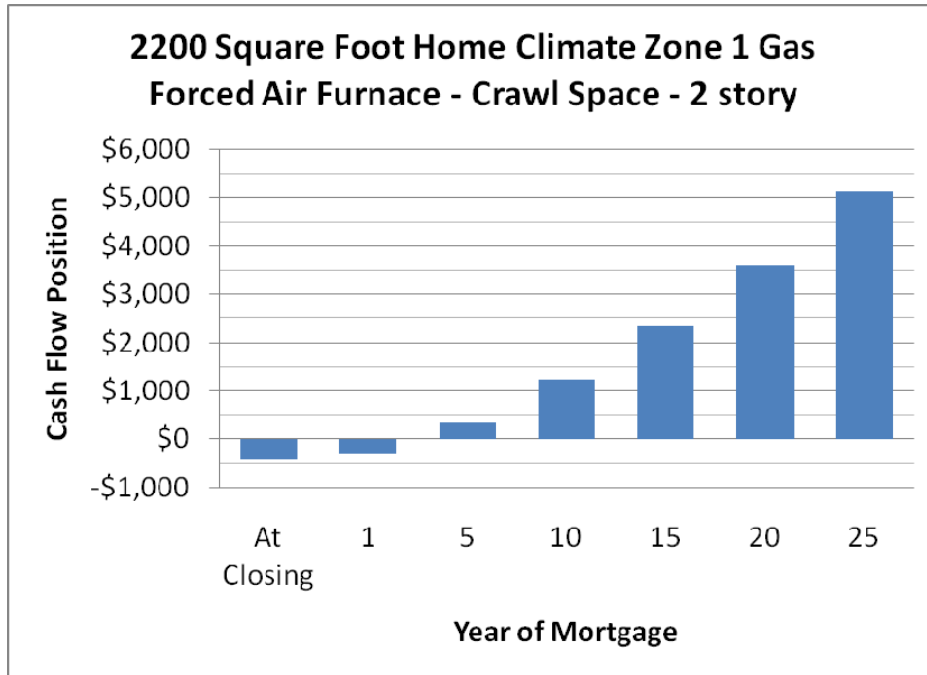
First cost range from \$0.50 to \$2.04 per square foot, depending on building size and heating system type. For average size gas heated homes, representing 75% of all new homes in Washington, the cost will be \$1.00 per square foot for climate zone one and \$2.04 per square foot for climate zone two. 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 energy savings for the average size gas heated home of 18 percent in climate zone 1 and 26 percent in climate zone 2. Energy savings in most other prototypes show 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). Positive cash flow varies from project to project. The vast 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. It should be noted that a number of the building prototypes analyzed will require a longer time period to achieve a positive cash position.

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		
		Year of home ownership		
Climate Zone 1		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	\$ 352	\$ 1241	\$ 2335
	Heat Pump	\$ 178	\$ 1014	\$ 2051
1350 SF, Crawlspace	Gas Furnace	\$ -95	\$ 105	\$ 376
	Heat Pump	\$ 150	\$ 652	\$ 1270
	Zonal (electric)	\$ 10	\$ 217	\$ 478
5001 SF, 2 stories, Basement	Gas Furnace	\$ 731	\$ 2101	\$ 3753
	Heat Pump	\$ 524	\$ 1721	\$ 3168
Climate Zone 2		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	\$ 506	\$ 1940	\$ 3718
	Heat Pump	\$ 631	\$ 2394	\$ 4540
1350 SF, Crawlspace	Gas Furnace	\$ -35	\$ 398	\$ 963
	Heat Pump	\$ 549	\$ 1667	\$ 3010
	Zonal (electric)	\$ 81	\$ 546	\$ 1,126
5001 SF, 2 stories, Basement	Gas Furnace	\$ 824	\$ 2687	\$ 4964
	Heat Pump	\$ 962	\$ 2976	\$ 5451

Introduction

In 2009, the Washington State Building Code Council adopted new rules for the Washington State Energy Code. This paper is focused on presenting a cash flow analysis of the adopted code changes. It compares the cost and savings difference between the 2006 WSEC and the 2009 WSEC. The adopted 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.

Adopted 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 duct leakage testing.

The 2009 WSEC implement additional requirements for building insulation, windows, heating systems controls and air leakage control as mandatory requirements for all new homes. In addition, the revisions included in the 2009 WSEC require permit applicants to apply an additional prescriptive requirement (Table 9-1). In most cases the permit applicant must chose one additional improvement from a list of options. This includes measures such as improved space heating equipment, improved water heating equipment, designs that further control HVAC system losses to the exterior, improved air leakage control and additional lighting requirements.

The conditioned floor area of the home is another aspect of energy consumption that is addressed by the final adopted rules. 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 adopted rule provides a reduced set of requirements for small homes (less than 1500 square feet) and an increased set of requirements for very large homes (more than 5000 square feet).

To implement the objectives noted above, a number of measures were approved. First there are a number of measures that apply to all new homes. These are implemented through the existing chapters 5 or 6 of the code. In addition, the code 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:

- Chapter 9 – Additional Energy Efficiency Options
- Residential Building Envelope
- Heat Pump Controls
- Building Air Leakage Testing
- Residential Lighting

Group R (residential) Change in Scope: [Section 101.3 Scope] Before we describe the adopted rules for single family, duplex and town home projects 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.

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 one of these options to qualify.***

- **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, no 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 two 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, one additional energy conservation measures must be specified for the project.¹ The available options from Table 9-1 follow:
- **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

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

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.

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.
- **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.

Residential Building Envelope [Table 6-1 and 6-2]

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

The tables below provide the most utilized prescriptive options for each climate zone from the 2006 WSEC followed by the 2009 WSEC. While the code provides numerous options for compliance, single family construction has been almost exclusively constructed using these options.

For climate zone 1, the principle change for 2009 is the reduction in glazing U factor. There is also the reduction of the allowed glazing area from unlimited to 25% of floor area in climate zone 1. Very few homes have glazing area exceeding 25% of floor area, making this a near universal standard for all homes.

For climate zone 2, the principle change for 2009 is the requirement for foam sheathing on the exterior walls (R-19+R5). While homes with less than 12% glazing to floor area ratio will not require this change, a large percentage of the construction will.

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.

2006 WSEC Table 6-1 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

WSEC 2009, Table 6-1 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
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'

2006 WSEC Table 6-2 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

2009 WSEC Table 6-2 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
III.	Unlimited	.30	.50	.20	R-49 or R-38 ADV	R-38	R-19+R-5	R-21 TB	R-12	R-30	R-10

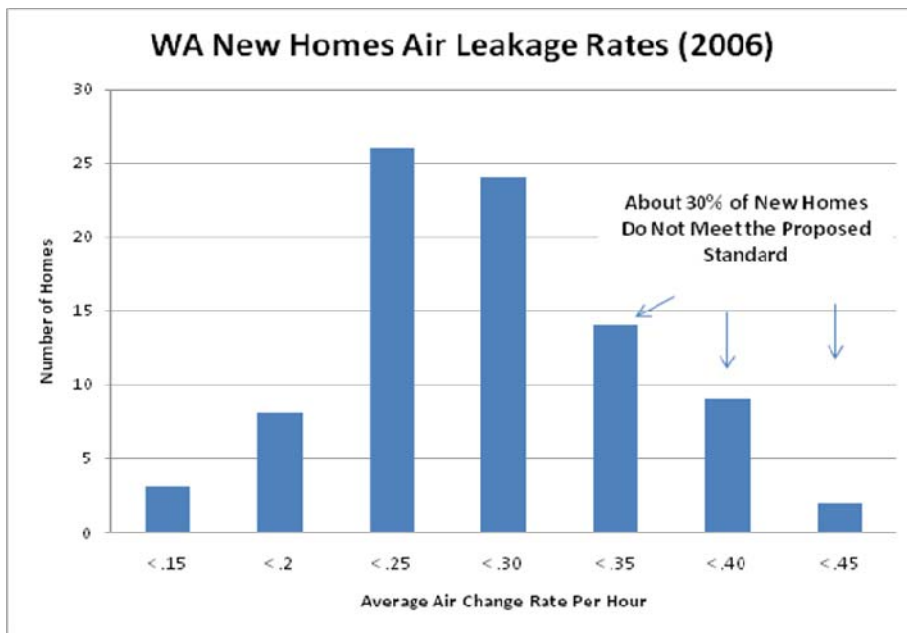
Heat Pump Controls: [Section 503.3.8.5] The adopted rules require all heat pumps controls to include an outdoor thermostat that locks out electric resistance heating elements when it is warm enough outside for the heat pump to provide all the space heat to the home. This improves the overall performance 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

Building Air Leakage Testing: [Section 502.4.5] The adopted rules require 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.

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

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

expanded in the coming year by utility programs⁶ and federal recovery act projects⁷. Additional training in this area is funded by DOE grants to the WSU Energy Program through 2010.

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 luminaires to include the pin based sockets and be equipped with a high efficiency lamp.

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.

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.

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 tables 6-1 and 6-2 and the options table (WSEC table 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 increased cost of code compliance compared to the 2006 WSEC would be \$0.50 to \$2.04 per square foot. For most home buyers, about 75% of new homes, the incremental cost will be represented by the 2200 SF gas heated home.

Table 1. 2009 Energy Code Compliance Costs

House size	Heating System	Incremental Cost	
		Zone 1	\$/ SF
2200 SF 1.5 story, crawlspace	Gas Furnace	\$2,110	\$1.00
	Heat Pump	\$2,686	\$1.22
1350 SF, Crawlspace	Gas Furnace	\$1,296	\$0.96
	Heat Pump	\$1,419	\$1.06
	Zonal (electric)	\$817	\$0.60
5001 SF, 2 stories, Basement	Gas Furnace	\$2,489	\$0.50
	Heat Pump	\$2,612	\$0.52
		Zone 2	\$/ SF
2200 SF 1.5 story, crawlspace	Gas Furnace	\$3,890	\$1.77
	Heat Pump	\$4,489	\$2.04
1350 SF, Crawlspace	Gas Furnace	\$2,044	\$1.51
	Heat Pump	\$2,167	\$1.61
	Zonal (electric)	\$1,578	\$1.17
5001 SF, 2 stories, Basement	Gas Furnace	\$4,221	\$0.84
	Heat Pump	\$4,344	\$0.87

Energy Savings Benefits

Table 2 summarizes the energy savings for the same example homes used in Table 2. The table includes Seattle, representative of climate zone 1 and the Spokane representative of climate zone 2.

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 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 adopted by the State Building Code Council.

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	1133	154
	Heat Pump	3454	0
1350 SF, Crawlspace	Gas Furnace	710	35
	Heat Pump	1964	0
	Zonal (electric)	941	0
5001 SF, 2 stories, Basement	Gas Furnace	2534	144
	Heat Pump	4236	0
Spokane			
2200 SF 1.5 story, crawlspace	Gas Furnace	1247	303
	Heat Pump	6607	0
1350 SF, Crawlspace	Gas Furnace	744	101
	Heat Pump	3800	0
	Zonal (electric)	1970	0
5001 SF, 2 stories, Basement	Gas Furnace	2685	284
	Heat Pump	7181	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	18	24
	Heat Pump	19	26
1350 SF, Crawlspace	Gas Furnace	8	14
	Heat Pump	14	21
	Zonal (electric)	6	11
5001 SF, 2 stories, Basement	Gas Furnace	16	21
	Heat Pump	19	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

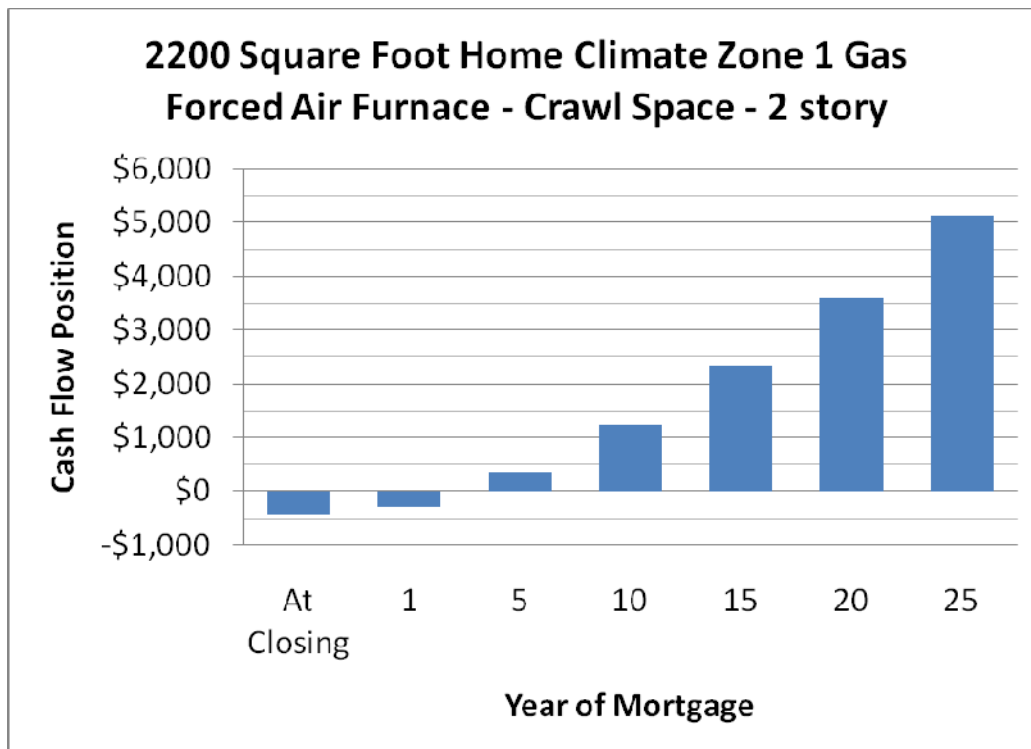
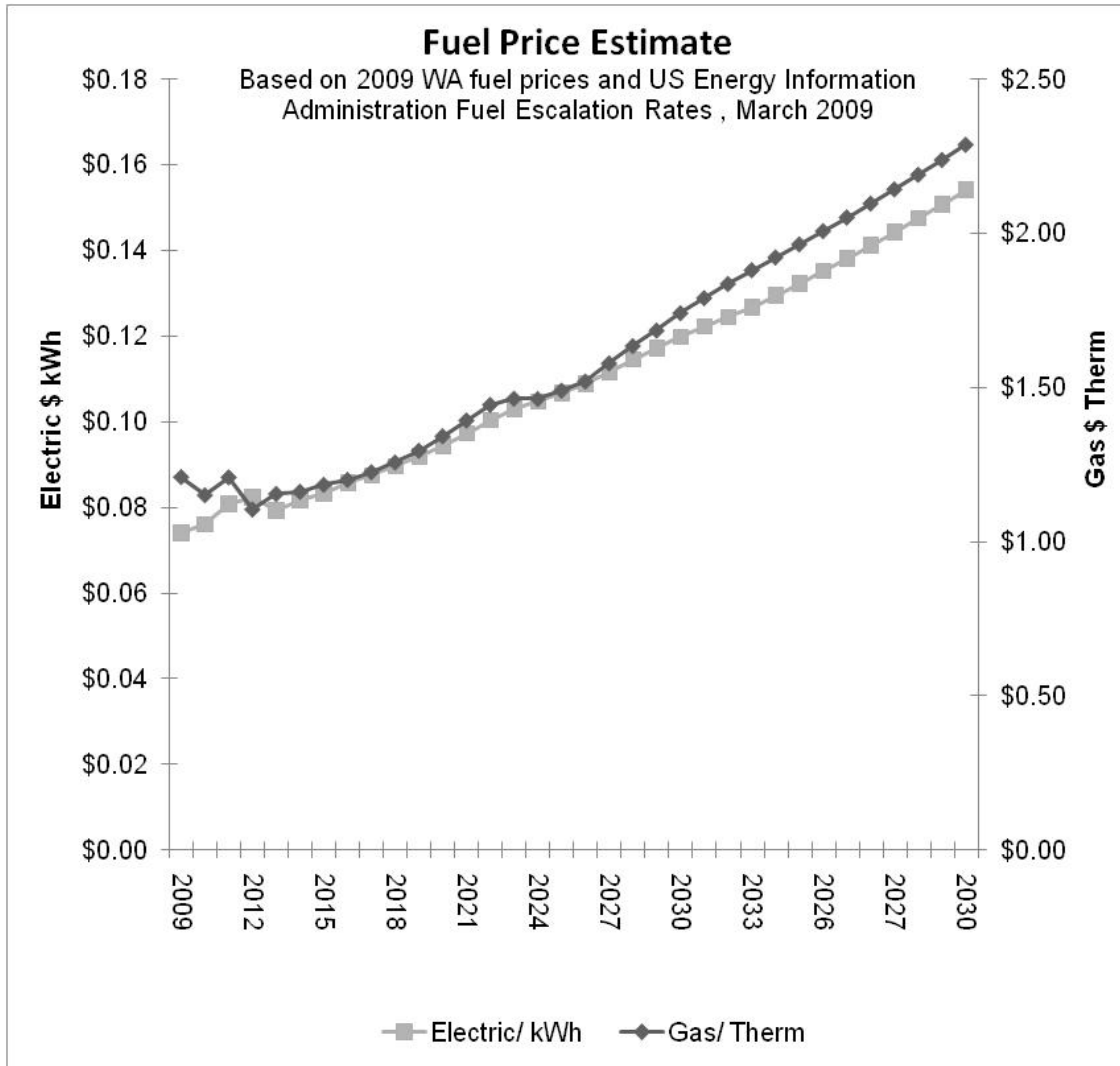


Table 4 Consumer Cash Flow Summary

House size	Heating System	Home Owner Cash Flow		
		Year of home ownership		
Climate Zone 1		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	\$ 352	\$ 1241	\$ 2335
	Heat Pump	\$ 178	\$ 1014	\$ 2051
1350 SF, Crawlspace	Gas Furnace	\$ -95	\$ 105	\$ 376
	Heat Pump	\$ 150	\$ 652	\$ 1270
	Zonal (electric)	\$ 10	\$ 217	\$ 478
5001 SF, 2 stories, Basement	Gas Furnace	\$ 731	\$ 2101	\$ 3753
	Heat Pump	\$ 524	\$ 1721	\$ 3168
Climate Zone 2		Year of home ownership		
		5	10	15
2200 SF 2 story, crawlspace	Gas Furnace	\$ 506	\$ 1940	\$ 3718
	Heat Pump	\$ 631	\$ 2394	\$ 4540
1350 SF, Crawlspace	Gas Furnace	\$ -35	\$ 398	\$ 963
	Heat Pump	\$ 549	\$ 1667	\$ 3010
	Zonal (electric)	\$ 81	\$ 546	\$ 1,126
5001 SF, 2 stories, Basement	Gas Furnace	\$ 824	\$ 2687	\$ 4964
	Heat Pump	\$ 962	\$ 2976	\$ 5451

Appendix A – Detailed Cash Flow Analysis



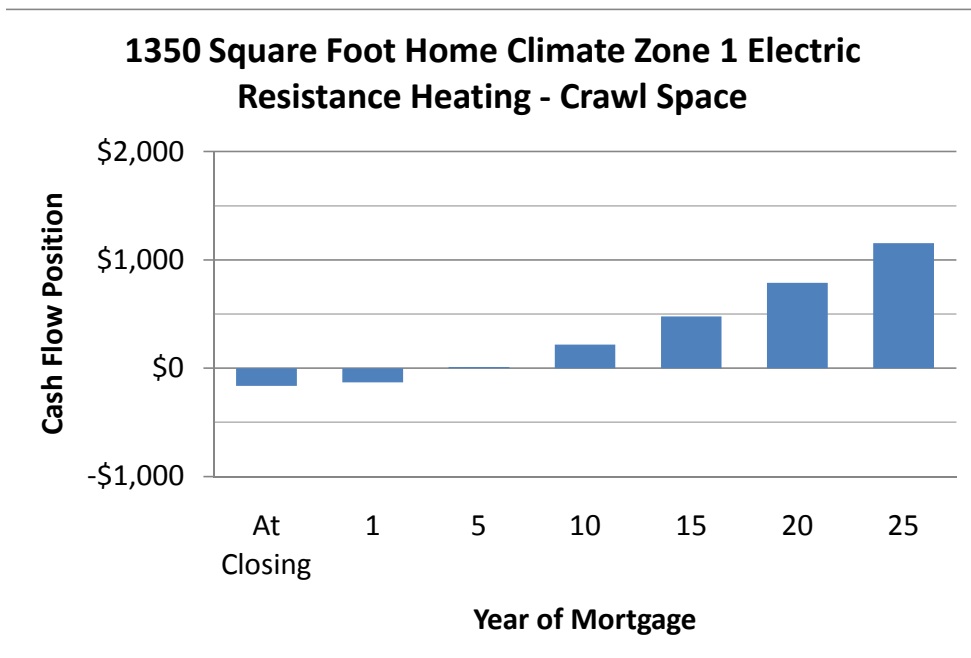
Incremental Cost above the existing code (2006 WSEC)

Measure	Cost	Data Source
Window U- 0.32	\$0.00	U-0.32 windows are currently available as the lowest cost code compliance window package.
Ceiling R-49 Standard	\$0.22 SF	NPCC Sixth Power Plan, Support documentation
Walls R-19+R5	\$0.87 SF	NPCC Sixth Power Plan, Support documentation
Below Grade Slab Thermal Break	\$0.90 LF	NPCC Sixth Power Plan, Support documentation. For basement homes only.
Blower Door Test	\$200 Home	NPCC Sixth Power Plan, Support documentation
HVAC System		
Heat Pump Lock Out Control	\$90 Home	NPCC Sixth Power Plan, Support documentation
Duct Testing	\$350 Home	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 Home	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. Unit	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. Unit	NPCC Sixth Power Plan, Support documentation
Lighting Pin based Luminaires	\$4.50 Socket	50 percent of all sockets to include the pin based sockets and high efficiency lamp. Cost based on 1.95 for the socket conversion (lockit-socket) and \$3.45 incremental cost for the high efficiency lamp.

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	Cost
Window	U 0.35	U.032	\$ -	0
Attic	R-38	R-49	\$ 0.22	\$ 297
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 99
Chapter 9 (NO credits required for small home)				
Sub Total				\$ 596
Overhead + taxes				1.37
Total				\$ 817
Cost per Square Foot				\$ 0.60

Energy Savings	Original
Therms	
kWh	941

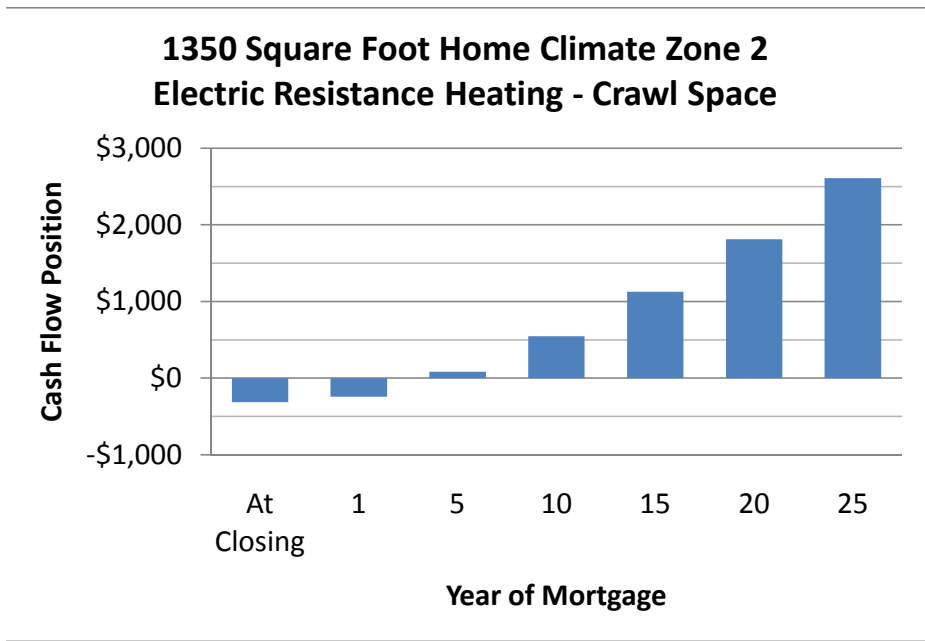


Small electric resistance heated homes represent about 3% of WA new housing stock

**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	Cost
Window	U 0.30	U 0.32	\$ -	\$ -
Attic	R-49	R-49	\$ -	\$ -
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 843
Lighting - 50% High Efficiency Luminaires			\$4.95	\$ 109
Chapter 9 (NO credits required for small home)				
Sub Total				\$ 1,152
Overhead + taxes				1.37
Total				\$ 1,578
Cost per Square Foot				
				\$ 1.17

Energy Savings		Orginal
	Therms	
	kWh	1970



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

1350 Square Foot Home Climate Zone 1

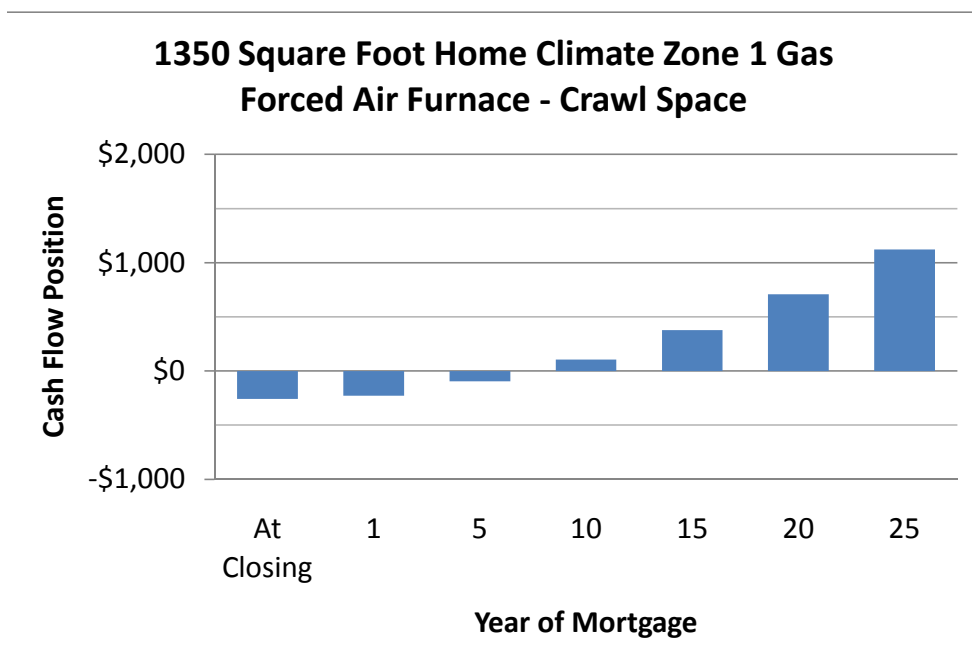
Gas Forced Air Furnace - Crawl Space

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
Duct Sealing (passed 2008)	NR	6% Max	\$ 350.00	\$ 350
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 99
Chapter 9 (NO credits required for small home)				
Sub Total				\$ 946
Overhead + taxes				1.37
Total				\$ 1,296

Cost per Square Foot				\$ 0.96
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Energy Savings		
	Therms	35
	kWh	710



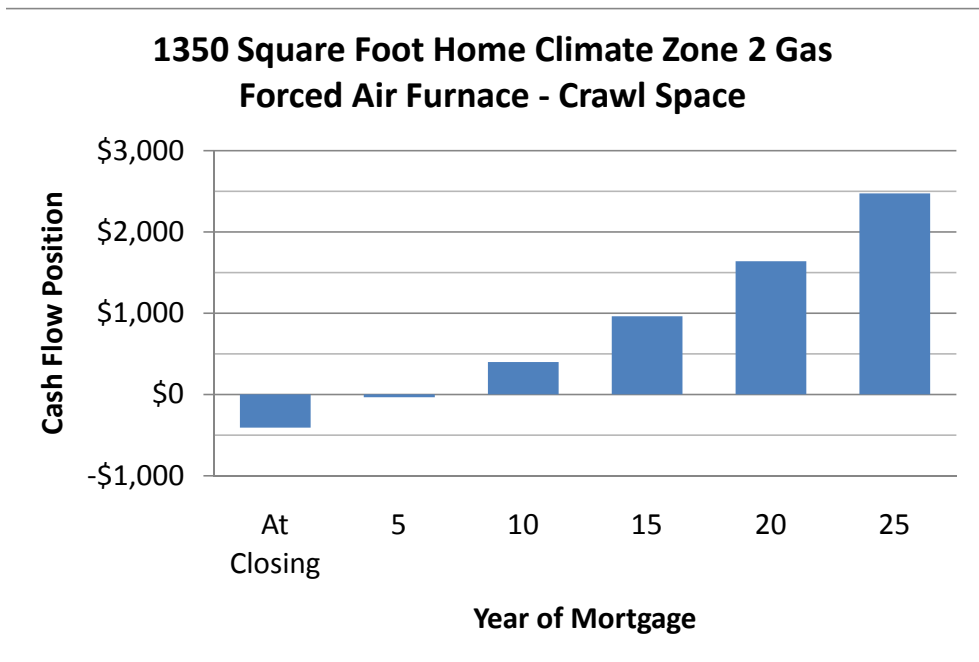
Small gas heated homes represent about 2% of WA new housing stock

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
Window	U 0.30	U 0.32	\$ -	\$ -
Attic	R-49	R-49		\$ -
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Duct Sealing (passed 2008)	NR	6% Max	\$ 350.00	\$ 350
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 843
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 99
Chapter 9 (1 NO credits required for small home)				
Sub Total				\$ 1,492
Overhead + taxes				1.37
Total				\$ 2,044

Cost per Square Foot				\$ 1.51
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Energy Savings		
	Therms	101
	kWh	744



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

1350 Square Foot Home - Seattle

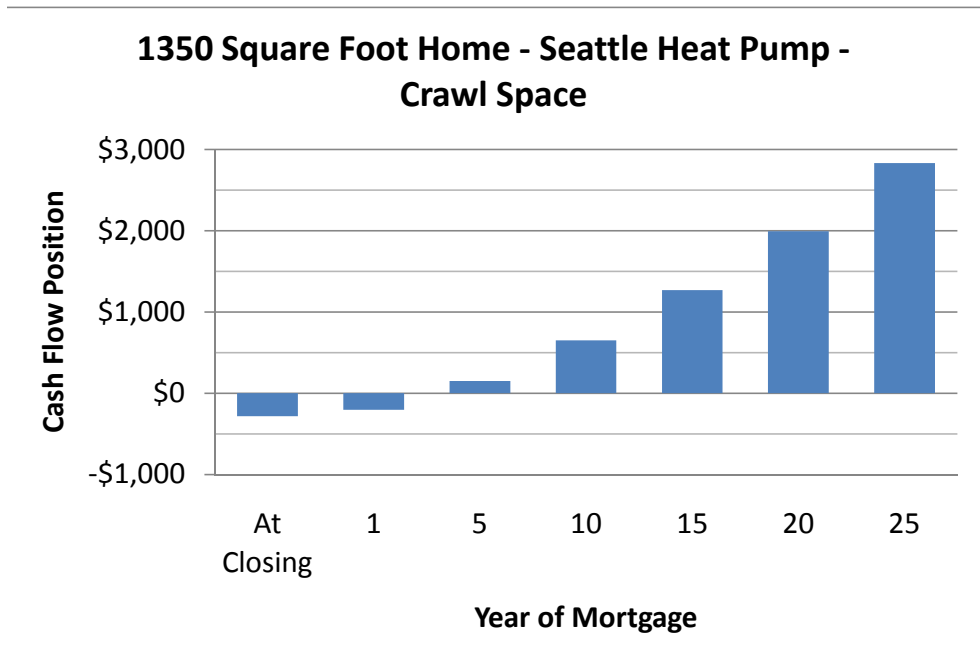
Heat Pump - Crawl Space

Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Windows	U - 0.35	U- 0.032	\$ -	
Attic	R-38	R-49	\$ 0.22	\$ 297
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Duct Sealing , (Adopted 2008)	NR	6% Max	\$ 350.00	\$ 350
Heat Pump Lock Out				\$ 90
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 99
Chapter 9 (NO credits required for small home)				
Sub Total				\$ 1,036
Overhead + taxes				1.37
Total				\$ 1,419

Cost per Square Foot				\$ 1.06
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Energy Savings	Units
Therms	
kWh	1964



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

1350 Square Foot Home - Spokane

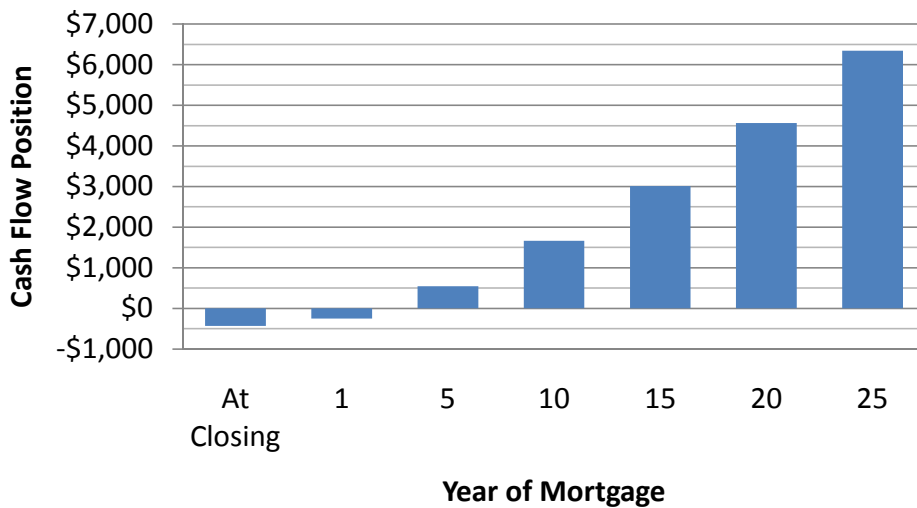
Heat Pump - Crawl Space

Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Window	U 0.30	U 0.32	\$ -	\$ -
Attic	R-49	R-49		
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Duct Sealing , (Base Case, Not required CH 9 Option 2)	NR	6% Max	\$ 350.00	\$ 350
Heat Pump Lock Out				\$ 90
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 843
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 99
Chapter 9 (NO credits required for small home)				
Sub Total				\$ 1,582
Overhead + taxes				1.37
Total				\$ 2,167
Cost per Square Foot				\$ 1.61

Energy Savings		Units
	Therms	
	kWh	3800

1350 Square Foot Home - Spokane Heat Pump - Crawl Space



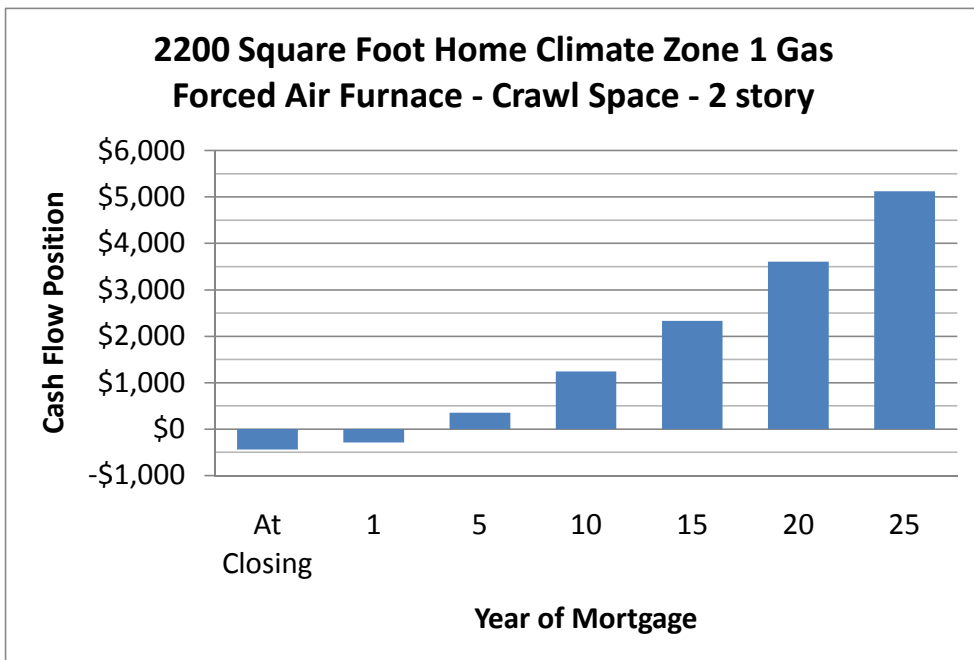
Small heat pump homes represent less than 1% of WA new housing stock

**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
Duct Sealing		6% Max	\$ 350.00	\$ 350
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 167
Chapter 9 (1 credits required)				
Option 1a, High Efficiency Equipment	80 % AFUE	92% AFUE	\$ 505.00	\$ 505
Sub Total				\$ 1,614
Overhead + taxes				1.37
Total				\$ 2,210

Cost per Square Foot				\$ 1.00
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Energy Savings	
	Therms 154
	kWh 1133



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

2200 Square Foot Home Climate Zone 1

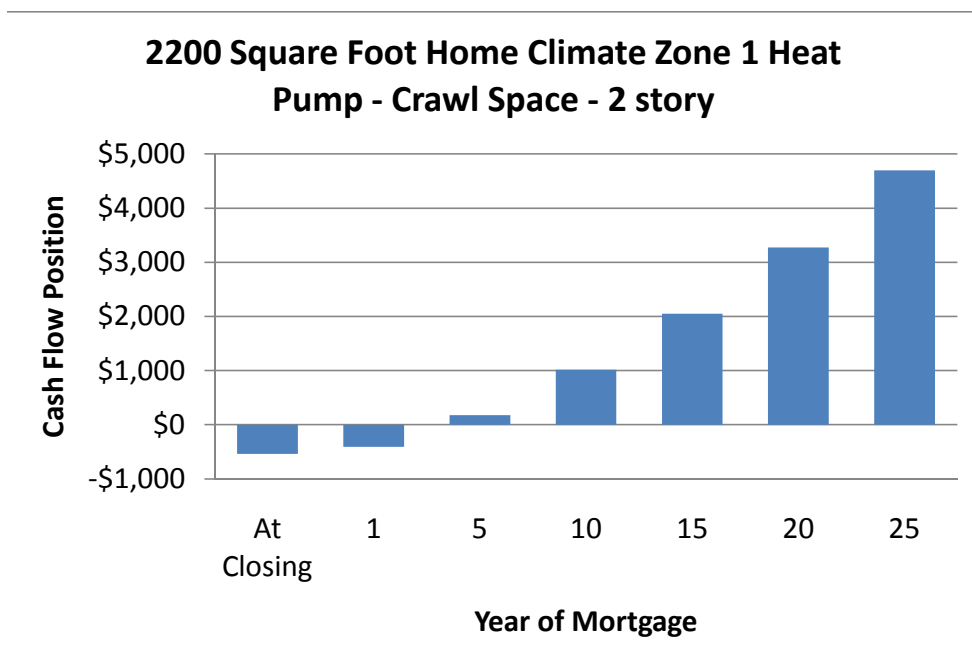
Heat Pump - Crawl Space - 2 story

Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Window	U 0.35	U- 0.32	\$ -	\$ -
Attic	R-38	R-49	\$ 0.22	\$ 392
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max	\$ 350.00	\$ 350
Heat Pump Lock Out				\$ 90
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 167
Chapter 9 (1 credits required)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	\$ 762.00	\$ 762
Sub Total				\$ 1,961
Overhead + taxes				1.37
Total				\$ 2,686

Cost per Square Foot				\$ 1.22
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Energy Savings		
	Therms	0
	kWh	3454



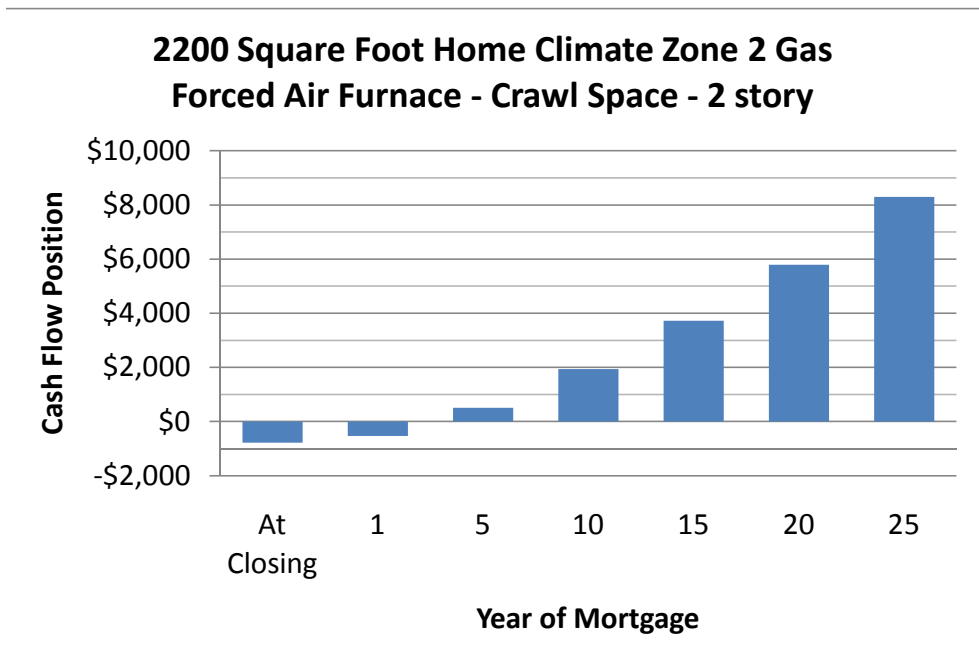
Medium size heat pump homes represent about 8% of WA new housing stock

**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
Window	U 0.30	U 0.32	\$ -	\$ -
Attic	R-49	R-49	\$ -	\$ -
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Duct Sealing (adopted 2008)		6% Max	\$ 350.00	\$ 350
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 1,618
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 167
Chapter 9 (1 credits required)				
Option 1a, High Efficiency Equipment	80 % AFUE	92% AFUE	\$ 505.00	\$ 505
Sub Total				\$ 2,840
Overhead + taxes				1.37
Total				\$ 3,890

Cost per Square Foot				\$ 1.77
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Energy Savings		
	Therms	303
	kWh	1247



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

2200 Square Foot Home Climate Zone 2

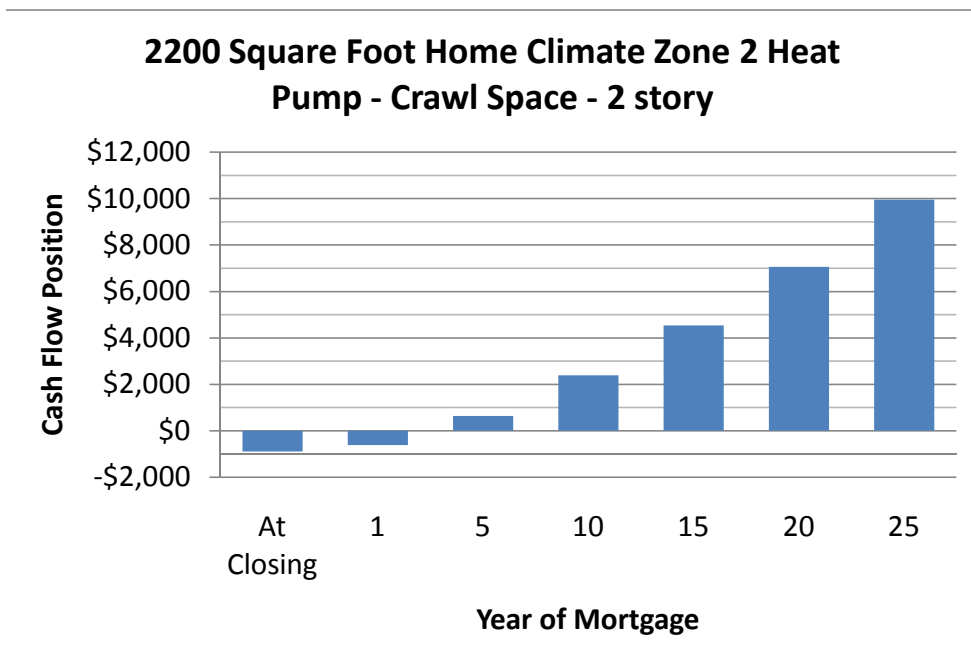
Heat Pump - Crawl Space - 2 story

Using Prescriptive Options

Upgrades To Base Code	2006 Code	2009 Proposed	Unit Cost	Total Cost
Window	U 0.30	U 0.32	\$ -	
Attic	R-49	R-49	\$ -	
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Heat Pump Lock Out				\$ 90
Duct Sealing , (adopted in 2008)	NR	6% Max	\$ 350.00	\$ 350
Heat Pump Lock Out				\$ 90
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 1,618
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 167
Chapter 9 (2 1 credits required)				
Option 1a, High Efficiency Equipment	7.7 HSPF	8.5 HSPF	\$ 762.00	\$ 762
Sub Total				\$ 3,277
Overhead + taxes				1.37
Total				\$ 4,489

Cost per Square Foot			\$ 2.04
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Energy Savings		
	Therms	0
	kWh	6607

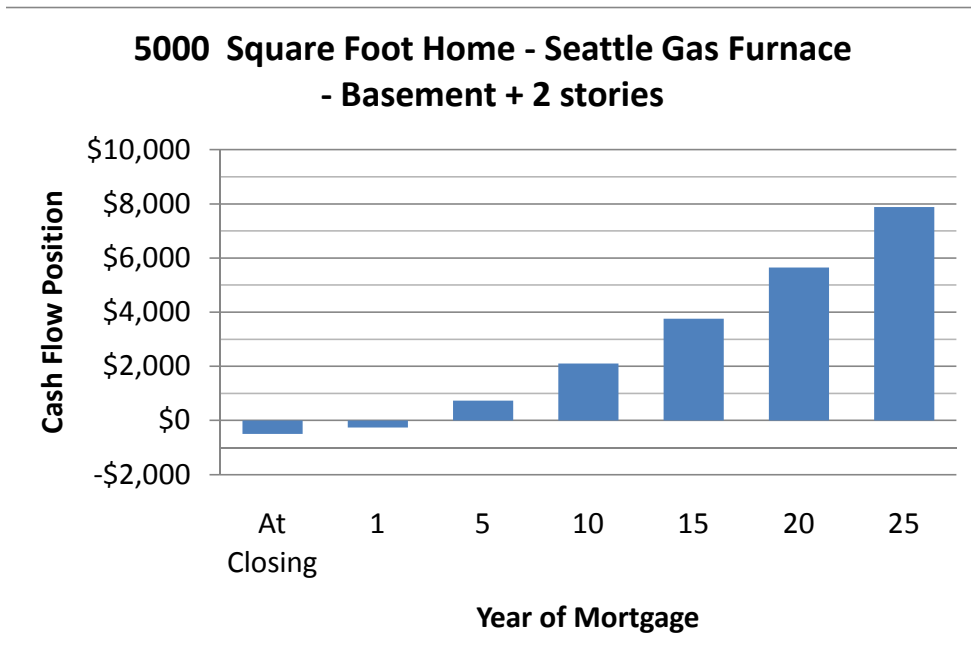


Medium size heat pump homes represent about 8% of WA new housing stock

**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	\$ -	
Attic	R-38	R-49	0.22 SF	\$ 366
Slab thermal break	Non TB	TB slab	.90 LF	\$ 126
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Lighting – 50% High Efficiency Lamps			\$ 1.50	
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 383
Chapter 9 (3 2 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			\$ -	\$ -
Sub Total				\$ 1,817
Overhead + taxes				1.37
Total				\$ 2,489
Cost per Square Foot				\$ 0.50

Energy Savings	Units
Therms	144
kWh	2534

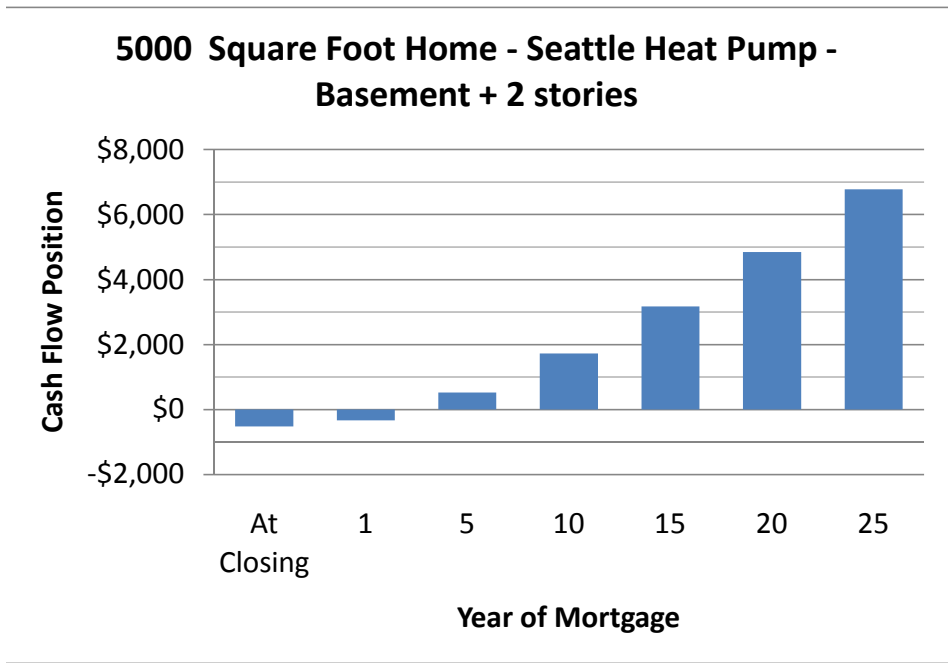


Large gas heated homes represent about 2% of WA new homes

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	\$ -	
Attic	R-38	R-49	0.22 SF	\$ 366
Slab thermal break	Non TB	TB slab	.90 LF	\$ 126
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Heat Pump lock out				\$ 90
Duct Sealing , (not required basement)	NR	6% Max		
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 383
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			\$ -	\$ -
Sub Total				\$ 1,907
Overhead + taxes				1.37
Total				\$ 2,612
Cost per Square Foot				\$ 0.52

Energy Savings	Units
	Therms
	kWh 4236



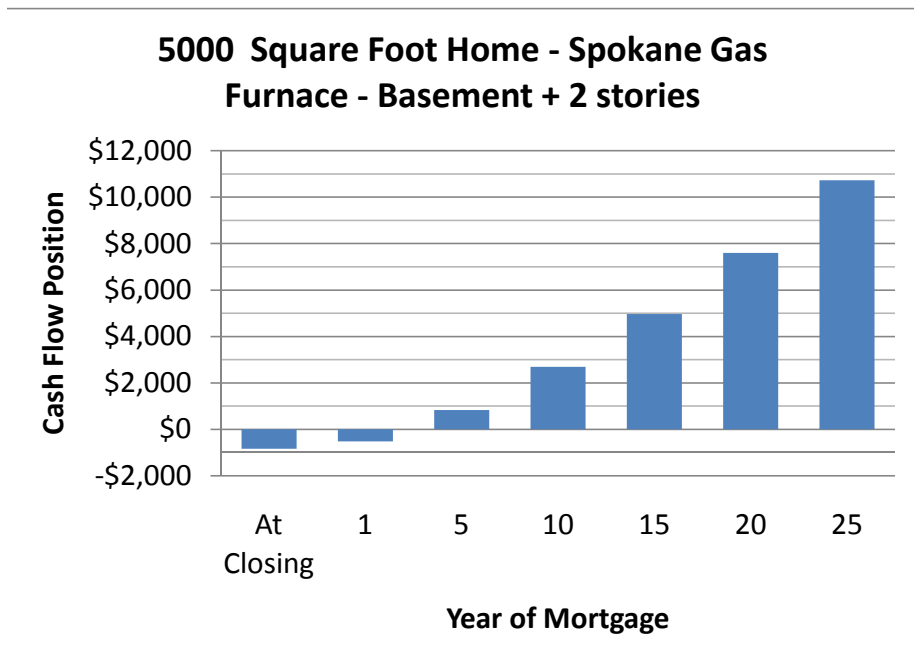
Large heat pump homes represent less than 1% of new WA homes

**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
Window	U 0.30	U 0.32		
Attic	R-49	R-49		
Slab thermal break	Non TB	TB slab	.90 LF	\$ 126
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
				\$ -
Duct Sealing , (not required ducts indoors)	NR	6% Max		
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 1,630
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 383
Chapter 9 (3 2 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			\$ -	\$ -
Sub Total				\$ 3,081
Overhead + taxes				1.37
Total				\$ 4,221

Cost per Square Foot				\$ 0.84
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Energy Savings		Units
	Therms	284
	kWh	2685

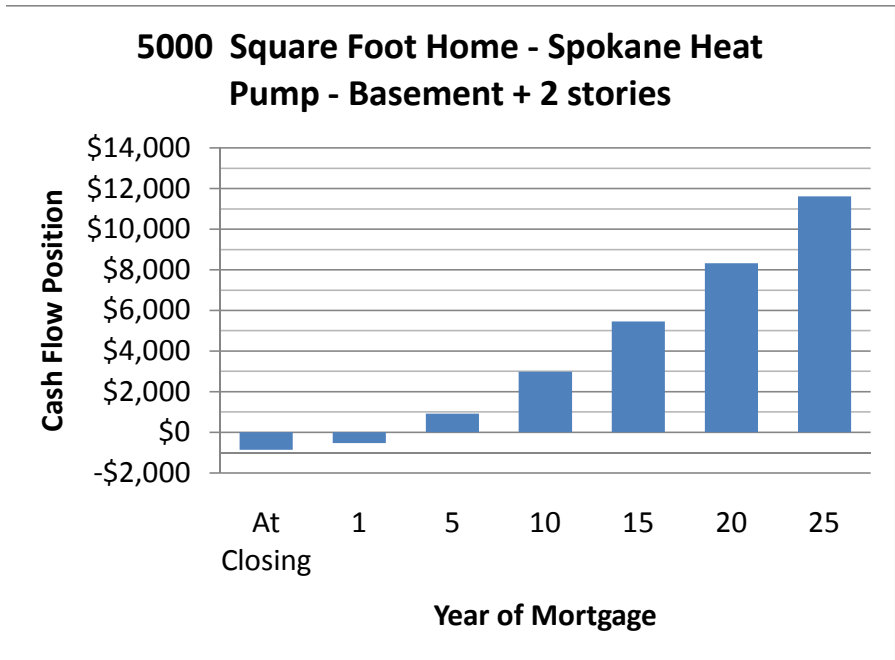


Large gas heated homes represent about 2% of WA new homes

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
Window	U 0.30	U 0.32	\$ -	
Attic	R-49	R-49		
Slab thermal break	Non TB	TB slab	.90 LF	\$ 126
Infiltration	Prescriptive	Tested	\$ 200.00	\$ 200
Heat Pump lock out				\$ 90
Duct Sealing , (not required CH 9 Option 2)	NR	6% Max		
Walls	R-21 int	R 19+R5	\$ 0.87	\$ 1,630
Lighting - 50% High Efficiency Luminaires			\$4.50	\$ 383
Chapter 9 (3 2 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			\$ -	\$ -
Sub Total				\$ 3,171
Overhead + taxes				1.37
Total				\$ 4,344
Cost per Square Foot				\$ 0.87

Energy Savings	Units
	Therms
	kWh
	7181



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