Cost Analysis of Potential Energy Code Improvements

December 2, 2016

Executive Summary

Oregon is considering developing a pathway for zero energy construction: buildings that produce as much energy as they consume. Washington and California have already established zero energy code pathways; these pathways are increasing energy efficiency, reducing climate pollution, and saving home and building owners and renters money. Questions have been raised in Oregon about how to achieve a similar pathway and what the impacts are on capital costs and energy efficiency.

A zero energy code pathway involves decreasing energy use in new buildings and homes in Oregon by 65 percent in three-year incremental stages over the next 15 years. To achieve such a trajectory, building codes would be updated regularly over the course of the 15-year period, achieving incremental reductions in energy use in new buildings and homes. The first two steps would be to improve building standards by about 10 percent, and then another 10 percent – presumed to occur over the course of 6 years. The methods and technology to achieve 20 percent savings are already well known in Oregon. Within Energy Trust territory about 40 percent of new homes were built above code in the past year and they averaged 20 percent savings above code. To examine these possible initial steps, this report assesses the incremental cost of constructing residential dwellings - both individual homes and multi-family buildings - to energy performance levels that exceed current Oregon code by 10 and the combined 20 percent.

While it is evident that significantly increasing energy efficiency in new homes and buildings would save Oregonians millions of dollars over time, the first costs incurred by the builder or developer to build a more efficient home or building are more uncertain. This analysis considers the potential up front cost impact improved energy codes would have on builders and developers. The cost information contained in this analysis represents close to a worst-case scenario (highest potential capital cost impacts) for a real-world builder. The project team took an exceptionally conservative approach in carrying out this assessment. The determination of construction costs for this analysis does not include:

- Preferred sub-contractor pricing, bulk pricing, or effective negotiation by a builder's purchasing agent.
- Cost savings accruing to the builder or developer based on optimized design that reduces mechanical system sizing or labor installation costs.
- Energy efficiency incentive funding for producing a higher performing home or building.
- Any expected incremental cost reductions between baseline and more energy efficient products that are likely to occur over time.

The analysis resulted in the following findings:

- Through energy modeling and cost estimating, the project team determined that incremental first year capital costs of more efficient construction practices ranged from a cost-neutral impact to a 4.1 percent increase when compared to current code, depending on the building type, location, and levels of energy performance.

- When analyzed using a financial model, any initial increase in the cost of construction required to achieve the higher levels of energy performance are repaid by utility savings in less than 1 year to up to 7 years of occupancy, depending on building type, location, and energy performance level.
- When utility costs are considered alongside financed construction costs over the life of the building, the analysis shows that building with improved energy efficiency standards costs 1.5% to 6.5% less than building under the current energy code.

	West side residential home		***East side residential home***	
Energy efficiency increase	*10%*	*20%*	*10%*	*20%*
Capital cost increase vs. current code	0.2%	1.7%	0.5%	1.7%
Cost recovery period	1 year	7 years	2 years	5 years
Decrease in total costs vs. current code (over life of building)	1.5%	2.2%	1.6%	3.0%

	West side multifamily building		***East side multifamily building***	
Energy efficiency increase	*10%*	*20%*	*10%*	*20%*
Capital cost increase vs. current code	1.2%	4.1%	1.2%	4.1%
Cost recovery period	2 years	4 years	2 years	4 years
Decrease in total costs vs. current code (over life of building)	6.0%	6.5%	6.0%	6.5%

Analysis Details

The analysis considers prototypical single-family home and multifamily buildings in both Hillsboro and Bend, in order to consider climate and geographical variations. The analytical process included first conducting an energy model of the prototype buildings. Various building components and technologies were input into the energy model to create scenarios in which the home or building achieved the desired performance levels. Those components and technologies were then catalogued in order for the project team to conduct research into common pricing. To ensure a balanced and transparent approach, the analysis uses publicly available retail pricing information. Additionally, some cost information was supplemented by information from Northwest Energy Efficiency Alliance (NEEA) cost research. The cost information used in the analysis does not take into account such factors as bulk pricing savings or labor cost savings that are often achieved by builders familiar with high performance construction techniques and approaches**.** This cost analysis also does not factor in energy efficiency incentive programs that can reduce the overall cost of certain energy efficiency components. Therefore, the project team believes the cost information used for this analysis represents close to a worst-case scenario (e.g. the highest potential capital cost impacts) for a real-world builder.

Building Type Overview

The report analyzes cost and savings for specific building designs for single family and multifamily projects. One design is used for all single family analysis and another is used for the multifamily work. The designs are actual examples recently built in Oregon. These prototype structures are:

- Single Family - In order to simulate typical single family housing activity, a 2,200 square foot, 3-bedroom home design was selected that the researchers have seen constructed on a regular basis in the Portland suburbs in the past two years. This two-story home has common design features such as an attached garage and an open living plan on the main floor. The home was modeled in both Hillsboro and Bend in order to determine if different energy efficiency measures were required to attain the same level of savings.
- Multifamily - A 44 unit, 26,088 square foot multifamily project was modeled for this project. The unit was chosen for its representative design. It is a low-rise building with walk-up entrances and no indoor common areas. The multifamily project was modeled in both Hillsboro and Bend, but the measures required to attain the varying levels of efficiency did not vary between the two locations.
- Heating Fuel Mix - When natural gas is available single family homes typically have gas heat. For this reason we modeled homes with gas heat, and gas water heating, at the 10 percent and 20 percent savings levels. In some parts of the state natural gas is unavailable and for that reason the research team also modeled the all-electric systems for homes at the 10 percent and 20 percent savings levels. New multifamily construction in Oregon typically uses electricity for heating and water heating. The utilization of gas water heating is a measure that is cost effective to employ when targeting mid-range savings. The 10 percent savings building was modeled with all electric systems and the 20 percent savings building was modeled with gas water heat and electric heat.

Energy Consumption Analysis

Approach: There are a variety of energy efficiency measures that could be employed to achieve greater than 10 percent savings in residential buildings in Oregon. We selected measures to include in this analysis based on what is commonly seen in homes that are seeking above code certification. The project team consults on a wider array of single and multifamily building projects across Oregon. The team has experience with large volume builders and custom home builders. The measures selected for this analysis to attain the 10 percent and 20 percent savings levels are those that are widely adopted by the volume contractors in the construction industry.

- REMRate modeling - The energy savings was estimated using the industry standard energy modeling software REM/Rate v15.2. This software tool analyzes the building's shell, HVAC systems, water heating, and lighting fixtures. REM/Rate bases its estimate of annual fuel usage on the efficiency of the building systems and uses standard assumptions of plug loads, hot water usage, thermostat settings, plus local weather data. The team member that conducted the modeling is an industry expert who conducts over 1,000 energy models annually and followed local protocols that have been developed to ensure accuracy in estimating energy savings.
- Energy Efficiency and Solar - In addition to considering the energy savings that is available from efficiency measures, we also considered the use of Solar Photovoltaic Panels (PV) as an additional measure. Currently Oregon energy code allows PV to be utilized to achieve code requirements. Since achieving the 10 percent and 20 percent savings levels are regularly achieved by builders without the use of PV, this option was not used in modeling those homes.

Single Family Energy Savings Measures

Fourteen different types of energy savings measures were analyzed for the purposes of this study. Within each measure type there were varying levels of efficiency modeled, for the team modeled savings for 4 different levels, 3 levels of attic insulation and two levels of wall insulation. The table below indicates what types of measures were included for single family homes to reach the different levels of energy savings.

Table 1: Single Family Measures

Measure Type	10% Savings	20% Savings
Water Heater	Yes	Yes
Heating Equip	Yes	Yes
Heating Distribution	Yes	Yes
Air Tightness	Yes	Yes
Heat Recovery Ventilation	-	-

Floor/Slab Insulation	-	-
Wall Insulation	-	Yes
Roof/Attic Insulation	In Bend Only	Yes
Plumbing Fixtures	-	-
Windows	-	Yes
Entry Doors	Yes	Yes
Hot Water Pipe Insulation	-	-
Lighting	Yes	Yes
Solar PV System	-	-

Multifamily Energy Savings Measures

The same types of measures that were analyzed for single family homes were also analyzed for the multifamily building in this study. The specific measures are sometimes different for the multifamily building, for instance Package Terminal Heat Pumps were modeled for the multifamily building, but not the single family building. Because the multifamily building is a walk-up building the team decided to model only unitary equipment. That means no central heating, ventilation, or water heating systems were analyzed even though those systems are typically very durable and may offer significant savings potential over unitary systems, especially if they are analyzed for lifecycle cost savings. Unitary systems are lower cost to install and the team decided the inclusion of those systems would represent the more conservative approach for this study.

Table 2: Multifamily Measures

Measure Type	10% Savings	20% Savings
Water Heater	Yes	Yes
Heating Equip	Yes	Yes
Heating Distribution	-	Yes
Air Tightness	Yes	Yes
Heat Recovery Ventilation	-	-
Floor/Slab Insulation	-	Yes
Wall Insulation	Yes	Yes
Roof/Attic Insulation	Yes	Yes

Plumbing Fixtures	-	Yes
Windows	Yes	Yes
Entry Doors	-	-
Hot Water Pipe Insulation	-	Yes
Lighting	Yes	Yes
Solar PV System	-	-

Estimating Measure First Costs

The baseline code buildings were estimated to cost $120 per square feet. This pricing was utilized for both single family and multifamily construction. Construction costs will vary depending on the quality of finish materials utilized and due to the availability of materials and labor. Costs can also differ significantly between multifamily and single family construction. The $120 per square foot cost was established as a level that is reasonable to consider for the size of buildings being considered and the types of finishes typical of housing for moderate income households. For example the window costs estimates are based on vinyl windows rather than on more expensive wood or fiberglass options. Additionally the home's two entry doors are assumed to be fiberglass with ¼ lites with double pane insulated glass.

Construction costs were held constant between Hillsboro and Bend. There may be differences between the two markets, but since most material suppliers have distribution capacity in both markets and construction practices are largely the same, the research team decided that the one price was representative.

Cost information for the efficiency measures modeled at the 10 percent and 20 percent buildings was readily available because the technologies and methods are used regularly by builders in Oregon today. Within Energy Trust of Oregon territory about 40 percent of new homes participate in their new homes program and the average savings over code is 20 percent. That represents over 3,000 homes built in the past year at this level of performance. NEEA has compiled cost data for the typical measures utilized to achieve that level of performance. This study uses that cost information from NEEA in addition to current pricing for equipment that was researched on internet retail sites. This equipment pricing does not reflect any contractor discounts and the team views this as a conservative cost approach.

Estimating Lifecycle Costs

A life cycle cost analysis was also conducted to offer a view of cost beyond merely first cost. Life cycle cost analysis is a decision-making tool that compares the owning and operating costs for energy using systems: heating, cooling, lighting, building envelope, and domestic hot water. The analysis accounts for the initial cost of constructing a building, as well as the cost of owning

and operating a facility over its useful life. These costs make up the total cost of ownership for a building. In addition to determining the first cost of constructing 10 percent and 20 percent above current code buildings, a lifecycle cost analysis was conducted using the Lifecycle Cost Analysis Tool, Version: 2016-A from the Office of Financial Management (OFM) in Washington state. This tool was based on a federal tool and was developed by OFM to plan state capital expenditures, but has also been adopted in Washington to analyze all energy code proposals and some affordable housing funding applications.

For this analysis, the replacement cost of measures was factored into the lifecycle cost analysis. Equipment, plumbing and light fixtures, solar panels were all estimated to have useful lives well short of 50 years. The length of a measure's useful life was held constant across various efficiency levels. In that way the lifecycle costs were not influenced by subjective determinations of how long a measure will last, but each measure type was treated the same. The replacement cost intervals for measures can be seen in the Cumulative Expenditure Report that is a part of each LCCT report in the Appendices.

Analysis Results

Table 3 below details the incremental increases in construction costs (first costs) required to achieve the above code levels of performance for the 2,200 square foot single family home. Incremental costs to achieve 10 percent savings in gas heated homes varied from 0.2 percent in Hillsboro to 0.5 percent in Bend. Although not shared in Table 3, the costs to achieve 10 percent savings for electric heat were estimated and totaled increased costs over code of 0.8 percent and 1.1 percent. The incremental costs for the 20 percent saving in gas heated homes were 1.7 percent for both from Hillsboro and Bend. The costs for 20 percent savings with electric heat were 2.2 percent in Hillsboro and 2.3 percent in Bend.

Table 3: Single Family Measure Capital Costs (First Costs)

Measure Type	10% Hillsboro Gas Heat	10% Bend Gas Heat	20% Hillsboro Gas Heat	20% Bend Gas Heat
Water Heater	$42	$42	$369	$369
Heating Equip	$180	$180	$237	$237
Heating Distribution	$296	$296	$296	$296
Air Tightness	$75	$75	$75	$75
Heat Recovery Ventilation	-	-	-	-
Floor/Slab Insulation	-	-	$1,485	$1,485

Wall Insulation	-	-	$946	$946
Roof/Attic Insulation	-	$715	$715	$715
Plumbing Fixtures	-	-	-	-
Windows	-	-	$400	$400
Entry Doors	$40	$40	$40	$40
Hot Water Pipe Insulation	-	-	-	-
Lighting	$0	$0	$0	$0
Solar PV System	-	-	-	-
Total Capital Cost Premium	$633	$1,348	$4,563	$4,563
Premium %	**0.2%**	**0.5%**	**1.7%**	**1.7%**

Note: The lighting upgrades were listed with a $0 cost due to two factors. Project teams have reported that they are able to find efficient fixtures and bulbs for no additional cost. The other factor is that the overall market is widely expected to move to LED bulbs in the near future.

Table 4 below details the incremental increases in construction costs (first costs) required to achieve the above code levels of performance for the 44 unit, 26,088 square foot low-rise multifamily project.

Table 4: Multifamily Measure Capital Cost per Unit (First Cost)

Measure Type	**10%**	**20%**
Water Heater	0$	$1,284
Heating Equip	$40	-
Heating Distribution	-	-
Air Tightness	$75	$75
Heat Recovery Ventilation	-	-
Floor/Slab Insulation	-	$451
Wall Insulation	$254	$254
Roof/Attic Insulation	$409	$409

Plumbing Fixtures	-	$61
Windows	$100	$200
Entry Doors	-	-
Hot Water Pipe Insulation	-	$168
Lighting	$0	$0
Solar PV System	-	-
Total Capital Cost Premium	$878	$2,902
Premium %	**1.2%**	**4.1%**

Financial Analysis

This analysis examines the financial impact of the proposed savings at a first year level and with a fifty-year lifecycle cost approach. Both approaches are based on the consideration of capital costs interest paid back through long term financing and the lowered operating costs that come with increased efficiency. The single family financing assumes a standard 30-year mortgage with a 4 percent interest rate. The multifamily financing assumes a 20-year mortgage with a 4 percent interest rate.

Five different building types were modeled for each climate location. The lowest cost home for in Bend and Hillsboro from a lifecycle perspective was the 20 percent more efficient gas home.

Table 6. Total 50 Year Costs for 2,200 Sq Ft Home (Lifecycle Cost)

	Bend	**Hillsboro**
Code Baseline (Gas/Elec)	$528,812/$530,420	$515,037/$513,974
10% Savings with Gas Heat	$520,355	$507,463
10 %Savings with Elec Heat	$529,494	$513,156
20% Savings with Gas Heat	$513,379	$503,753
20% Savings with Elec Heat	$523,900	$509,100

For all savings scenarios the first year expenses are lower than the baseline code home. For instance the first year expenditures for the 20 percent savings home in Hillsboro are $125 less than the baseline and in year 7 of occupancy the cumulative savings over baseline becomes positive and remains so for the rest of the building's estimated life.

The numbers of years of occupancy required before the cumulative expenses of the savings scenarios overcome the initial capital expense varies between 1 and 7 years.
For the 10% savings level these time periods are:

- 2 years for the cumulative expenses of a multifamily building to become less than those of a code building in either Oregon climate location.
- 2 years for the cumulative expenses of a gas heated single family home in Bend to become less than those of a code built home.
- 1 years for the cumulative expenses of a gas heated single family home in Hillsboro to become less than those of a code built home.

For the 20% savings level these time periods are:

- 4 years for the cumulative expenses of a multifamily building to become less than those of a code building in either Oregon climate location.
- 5 years for the cumulative expenses of a gas heated single family home in Bend to become less than those of a code built home.
- 7 years for the cumulative expenses of a gas heated single family home in Hillsboro to become less than those of a code built home.

Both the 10 percent and 20 percent better than code homes are better investments than the baseline code home, but the 20 percent savings homes are better long-term investments. This understanding provides a good motivation to move state building standards for single family homes towards higher levels of energy performance as quickly as is feasible for the building community to adopt the required methods.

The multifamily building built to 10 percent and 20 percent savings level show lower first costs and lifecycle costs than the baseline code building. The lower incremental costs associated with these levels of performance means that project owners will recover the initial incremental investment much faster. The 10 percent building fully recovers the additional capital costs in the second year of occupancy. The 20 percent building recovers the additional capital costs in the fourth year of occupancy. The net present savings for the 10 percent building are $410,887. The net present savings for the 10 percent building are $436,341.

The lifecycle savings potential indicated for these higher energy performing buildings supports policies that promote buildings that are capable of supplying even higher level of savings than the 20 percent documented in this analysis. The savings provided by the 10 percent and 20 percent buildings comes with very little risk. Both building levels pay back the initial capital expense of energy efficiency measures within four years. This rapid repayment schedule should make policy makers secure in setting these levels of energy performance for multifamily construction projects as standard practice in the very near term.

Study Conclusions

The first year and lifecycle cost savings represented by the 10 percent and 20 percent savings levels are significant and they should be adopted into code as quickly as possible. The initial costs of construction required to achieve these levels of performance are minimal - if not cost

neutral - and are quickly repaid by the utility savings. These levels of energy performance require between 1 to 7 years when using the most cost effective heating fuel for a given location and building type. The 20 percent savings level is the average that Energy Trust of Oregon sees with participating new homes and it utilizes methods that are very common across Oregon. This building type fully recovers upfront costs within four years of operation. That is a very secure provision of benefit to Oregon building owners and occupants.

Interestingly, the lifecycle savings potential for very high energy performing multifamily buildings could be significantly greater than baseline current code options. While this analysis focused on the short-term cost impact of making 10 percent and 20 percent code improvements, market evidence of a few recent projects completed in Oregon suggest that multifamily construction that achieves very high energy performance improvement levels has an even lower overall cost in the first year of operation and over a 50-year lifecycle. One of these examples is Phase Two of Orchards at Orenco Station in Hillsboro, with Walsh Construction as the contractor and REACH CDC as the developer. This project was designed to deliver over 50% energy improvement and was completed for only a 5% incremental cost in 2016. The project team achieved the savings at this price as the result of discipline to design and build with energy efficiency as a priority. Another high performance project completed in 2016 is the Iron Horse Lodge in Prineville, built by Pacific Crest Affordable Housing, which delivered a 75% energy improvement through a mix of efficiency and solar. This project will achieve close to zero energy usage, meaning that over the course of a year it will consume almost the same amount of energy as is produced on site. The full cost recovery of all of the energy investments will occur in 10 years. At the same time, the greatly reduced operating expenses that accrue on day 1 of occupancy help the building owner keep rents lower and ensures that month utility costs can be affordable for these low-income seniors on a fixed income.

Any first cost premiums for higher levels of energy performance should decrease over time as contractors become more familiar with the construction of efficient building assemblies, products become more widely available and heat pump technologies increase efficiency. As an example, the installed cost of solar PV has dropped more than 50% in the past 10 years and is likely to continue dropping in cost. Yet, even with first cost premiums, these project produce a lower overall cost in the first year of operation and over a 50-year lifecycle when compared to less efficient buildings, including current code buildings. Indeed, a multifamily building with 65% better energy performance than current code (equivalent to being “zero energy ready”) is an estimated 11.2% less expensive to build and operate over time than a code building.

While the practices needed to achieve 20 percent energy improvement are commonplace and easily integrated into standard building practices today, a greater number of contractors must become familiar with the advanced building practices required to achieve levels such as 65 percent before they can become standard practice (i.e. code). Nonetheless, the spread of those techniques and the achievement of that level of energy performance should be reasonably achieved over the next 15 years.

Appendices

Appendix A: Incremental Costs
Appendix B-1: LCCT Executive Report for Multifamily 10 percent and 20 percent Savings
Appendix B-2: LCCT Exec. Rep. for Hillsboro Gas Heat Single Family 10 percent and 20 percent Savings
Appendix B-3: LCCT Exec. Rep. for Hillsboro Elec Heat Single Family 10 percent and 20 percent Savings
Appendix B-4: LCCT Exec. Rep. for Bend Gas Heat Single Family 10 percent and 20 percent Savings
Appendix B-5: LCCT Exec. Rep. for Bend Elec Heat Single Family 10 percent and 20 percent Savings
Appendix C-1: LCCT Expenditure Report for Multifamily 10 percent and 20 percent Savings
Appendix C-2: LCCT Expenditure Report for Hillsboro Gas Heat Single Family 10 percent and 20 percent Savings
Appendix C-3: LCCT Expenditure Report for Bend Gas Heat Single Family 10 percent and 20 percent Savings

Appendix A: Incremental Cost Sources

	Single Family Costs	Multifamily Costs				
		2200	sq ft		593	sq ft
	SF	SF	SF	MF	MF unit	MF
	Code prices	Improved prices	Premium	Code price	Improved p	Premium
Total Premium						
Percent Premium						
.63 Gas WH-50 gal	$506.00	$548.00	$42.00			$0.00
.67 Gas WH-50 gal	$506.00	$875.00	$369.00			$0.00
.96 Gas WH-50 gal	$506.00	$1,790.00	$1,284.00	$506.00	$1,790.00	$1,284.00
.90 EF Elec WH-50 gal	$585.00	$585.00	$0.00			$0.00
.92 EF Elec WH-50 gal	$585.00	$585.00	$0.00			$0.00
.95 EF Elec WH-50 gal	$585.00	$585.00	$0.00			$0.00
.96 EF Elec WH-50 gal	$585.00	$585.00	$0.00			$0.00
HPWH 3.25 COP	$570.00	$990.00	$420.00	$570.00	$990	$420.00
92 AFUE furnace	$585.00	$765.00	$180.00			$0.00
95 AFUE furnace	$585.00	$822.00	$237.00			$0.00
8.5 HSPF ducted HP		$1,710.00	$1,710.00			$0.00
9.0 HSPF ducted HP		$2,220.00	$2,220.00			$0.00
PTHP 9.0 HSPF/15SEER			$0.00	$660.00	$700	$40.00
DHP 11 HSPF	$300.00	$1,270.00	$970.00	$200.00	$1,270	$1,070.00
DHP 12.5 HSPF	$300.00	$1,820.00	$1,520.00	$200.00	$1,820	$1,620.00
6% duct leakage		$296.00	$296.00			$0.00
Ducts inside			$0.00			$0.00
6 ACH		$75	$75.00		$75	$75.00
5 ACH		$75	$75.00		$75	$75.00
3 ACH		$150	$150.00		$150	$150.00
.05 ACH-Passive House			$0.00		$1,472	$1,471.68
HRV 80%		$2,000.00	$2,000.00			$0.00
HRV 90%		$3,000.00	$3,000.00			$0.00
2 gpm H2O fixtures		$183.16	$183.16		$61	$61.05
50% CFL			$0.00			$0.00
80% CFL			$0.00			$0.00
100% CFL			$0.00			$0.00
100% LEDs			$0.00			$0.00
DHW pipe insulation		$186.00	$186.00		$112	$112.06
2500 W PV system		$7,875.00	$7,875.00			$0.00
2650 W PV system		$8,347.50	$8,347.50			$0.00
84000 W PV system			$0.00			$0.00
85000 W PV system			$0.00			$6,085.23
R30 Floors			$0.00			$0.00
R38 Floors		$1,485.00	$1,485.00			$0.00
R15P Slab			$0.00		$451	$451.07
R15U Slab			$0.00		$702	$701.75
R23 Walls		$946.00	$946.00		$254	$253.50
R44 Walls		$6,226.00	$6,226.00		$2,700	$2,700.12
R38 Ceiling-14 heel		$759.00	$759.00		$409	$409.11
R49 Ceiling-7 heel		$715.00	$715.00		$385	$385.39
R60 Ceiling-7 heel		$825.00	$825.00		$877	$877.19
U .30 windows		$400.00	$400.00		$100	$100.00
U .28 windows		$688.00	$688.00		$200	$200.00
U .20 windows		$1,400.00	$1,400.00		$3,092	$3,091.53
R5 doors		$40.00	$40.00			$0.00
Base construction cost	$120.00	per sf				
Modeled MF Avg Unit Sq FT	593	Sq Ft				
Modeled MF avg Roof/unit	198	sq ft				

Appendix B-1: LCCT Executive Report for Multifamily 10 percent and 20 percent Savings

Office of Financial Management
Olympia, Washington - Version: 2016-A
Life Cycle Cost Analysis Tool

Executive Report

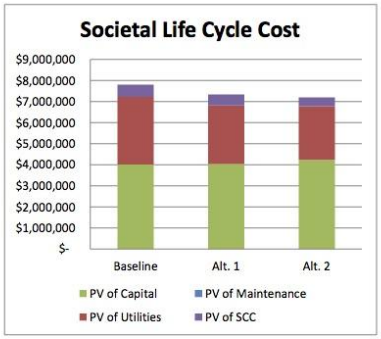
Project Information	
Project:	OR Affordable Housing Project: 10% and 20% Savings
Address:	
Company:	
Contact:	
Contact Phone:	
Contact Email:	

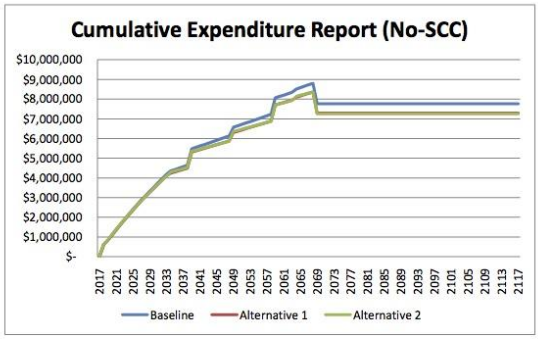
Key Analysis Variables		Building Characteristics	
Study Period (years)	52	Gross (Sq.Ft)	26,088
Nominal Discount Rate	3.46%	Useable (Sq.Ft)	26,088
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2017	Project Phase	0
Construction Years	2	Building Type	0

Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	39.5	35.7	33.6
1st Construction Costs	$ 3,115,269	$ 3,151,962	$ 3,238,924
PV of Capital Costs	$ 4,004,245	$ 4,034,676	$ 4,230,197
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 3,216,109	$ 2,774,522	$ 2,552,911
Total Life Cycle Cost (LCC)	**$ 7,220,354**	**$ 6,809,198**	**$ 6,783,108**
Net Present Savings (NPS)	**N/A**	**$ 411,155**	**$ 437,246**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	6,472	5,849	4,665
% CO2e Reduction vs. Baseline	N/A	10%	31%
Present Social Cost of Carbon (SCC)	$ 580,886	$ 524,979	$ 418,687
Total LCC with SCC	**$ 7,801,240**	**$ 7,334,177**	**$ 7,201,795**
NPS with SCC	**N/A**	**$ 467,062**	**$ 599,445**





Baseline Short Description
Affordable Multifamily with cost of $120/sf
Alternative 1 Short Description
10% better than code, 1.2% cost premium
Alternative 2 Short Description
20% better than code, 4.1% cost premium

Appendix B-2: LCCT Exec. Rep. for Hillsboro Gas Heat Single Family 10 percent and 20 percent Savings

Office of Financial Management
Olympia, Washington - Version: 2016-A
Life Cycle Cost Analysis Tool

Executive Report

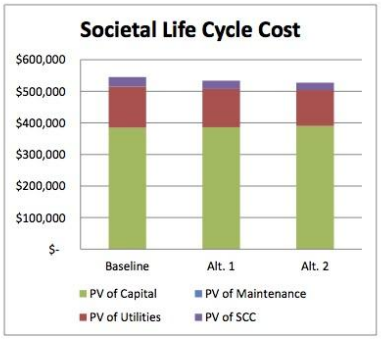
Project Information	
Project:	OR 2,200 SF Home Gas Heat: 10% and 20% Savings
Address:	123 St, Hillsboro,
Company:	
Contact:	
Contact Phone:	
Contact Email:	

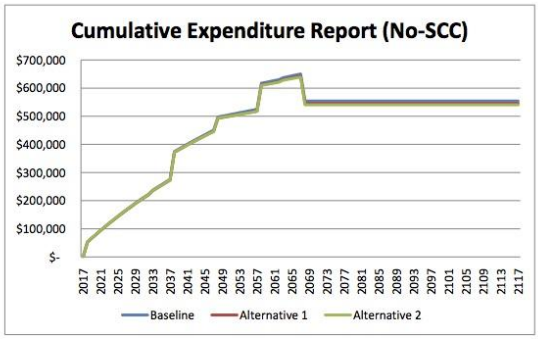
Key Analysis Variables		Building Characteristics	
Study Period (years)	51	Gross (Sq.Ft)	2,200
Nominal Discount Rate	3.46%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2017	Project Phase	0
Construction Years	1	Building Type	0

Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	40.0	36.0	31.3
1st Construction Costs	$ 262,841	$ 263,472	$ 267,384
PV of Capital Costs	$ 384,499	$ 386,125	$ 390,291
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 130,538	$ 121,339	$ 113,462
Total Life Cycle Cost (LCC)	**$ 515,037**	**$ 507,463**	**$ 503,753**
Net Present Savings (NPS)	**N/A**	**$ 7,574**	**$ 11,284**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	338	296	262
% CO2e Reduction vs. Baseline	N/A	12%	25%
Present Social Cost of Carbon (SCC)	$ 30,194	$ 26,464	$ 23,479
Total LCC with SCC	**$ 545,231**	**$ 533,928**	**$ 527,232**
NPS with SCC	**N/A**	**$ 11,304**	**$ 17,999**





Baseline Short Description
Single Family Construction with cost of $120/sf
Alternative 1 Short Description
10% better than code with Gas Heat, 0.2% cost premium
Alternative 2 Short Description
20% better than code with Gas Heat, 1.7% cost premium

Appendix B-3: LCCT Exec. Rep. for Hillsboro Elec Heat Single Family 10 percent and 20 percent Savings

Office of Financial Management
Olympia, Washington - Version: 2016-A
Life Cycle Cost Analysis Tool

Executive Report

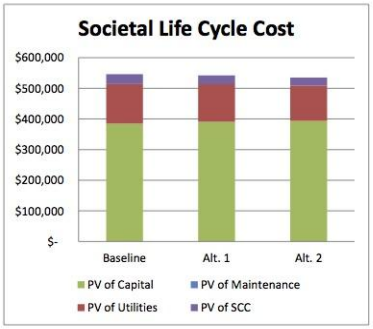
Project Information	
Project:	OR 2,200 SF Home: 10% and 20% Savings
Address:	123 St, Hillsboro,
Company:	
Contact:	
Contact Phone:	
Contact Email:	

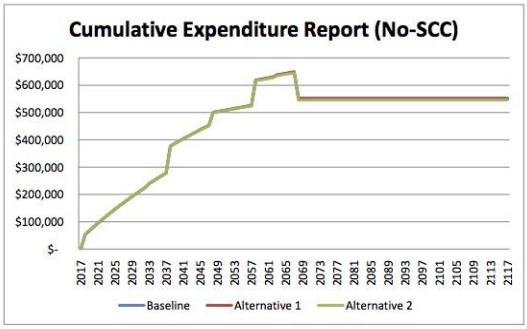
Key Analysis Variables		Building Characteristics	
Study Period (years)	51	Gross (Sq.Ft)	2,200
Nominal Discount Rate	3.46%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2017	Project Phase	0
Construction Years	1	Building Type	0

Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	26.5	24.0	21.5
1st Construction Costs	$ 262,841	$ 264,953	$ 268,484
PV of Capital Costs	$ 384,499	$ 390,732	$ 393,710
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 129,475	$ 122,424	$ 115,391
Total Life Cycle Cost (LCC)	**$ 513,974**	**$ 513,156**	**$ 509,100**
Net Present Savings (NPS)	**N/A**	**$ 818**	**$ 4,874**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	358	325	292
% CO2e Reduction vs. Baseline	N/A	9%	20%
Present Social Cost of Carbon (SCC)	$ 32,045	$ 29,071	$ 26,104
Total LCC with SCC	**$ 546,020**	**$ 542,227**	**$ 535,204**
NPS with SCC	**N/A**	**$ 3,793**	**$ 10,815**





Baseline Short Description
Single Family Construction with cost of $120/sf
Alternative 1 Short Description
10% better than code with Elec Heat, 0.8% cost premium
Alternative 2 Short Description
20% better than code with Elec Heat, 2.2% cost premium

Appendix B-4: LCCT Exec. Rep. for Bend Gas Heat Single Family 10 percent and 20 percent Savings

Office of Financial Management
Olympia, Washington - Version: 2016-A
Life Cycle Cost Analysis Tool

Executive Report

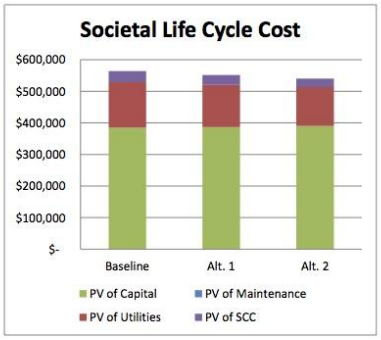
Project Information	
Project:	OR 2,200 SF Home: 10% and 20% Savings
Address:	123 Central Oregon St, Bend,
Company:	
Contact:	
Contact Phone:	
Contact Email:	

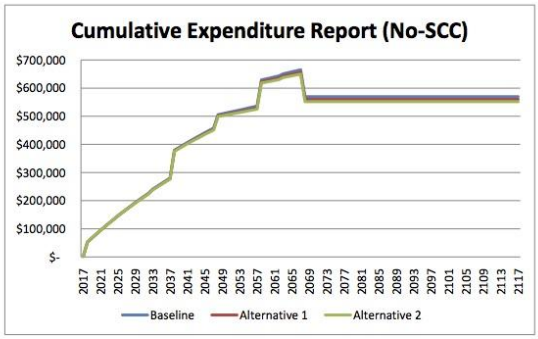
Key Analysis Variables		Building Characteristics	
Study Period (years)	51	Gross (Sq.Ft)	2,200
Nominal Discount Rate	3.46%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2017	Project Phase	0
Construction Years	1	Building Type	0

Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	49.4	44.3	38.3
1st Construction Costs	$ 262,841	$ 264,184	$ 267,384
PV of Capital Costs	$ 384,499	$ 386,655	$ 390,291
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 144,312	$ 133,700	$ 123,088
Total Life Cycle Cost (LCC)	**$ 528,812**	**$ 520,355**	**$ 513,379**
Net Present Savings (NPS)	**N/A**	**$ 8,456**	**$ 15,433**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	394	346	301
% CO2e Reduction vs. Baseline	N/A	12%	27%
Present Social Cost of Carbon (SCC)	$ 35,218	$ 30,978	$ 26,904
Total LCC with SCC	**$ 564,030**	**$ 551,333**	**$ 540,283**
NPS with SCC	**N/A**	**$ 12,697**	**$ 23,747**





Baseline Short Description
Single Family Construction with cost of $120/sf
Alternative 1 Short Description
10% better than code with Gas Heat, 0.5% cost premium
Alternative 2 Short Description
20% better than code with Gas Heat, 1.7% cost premium

Appendix B-5: LCCT Exec. Rep. for Bend Elec Heat Single Family 10 percent and 20 percent Savings

Office of Financial Management
Olympia, Washington - Version: 2016-A
Life Cycle Cost Analysis Tool

Executive Report

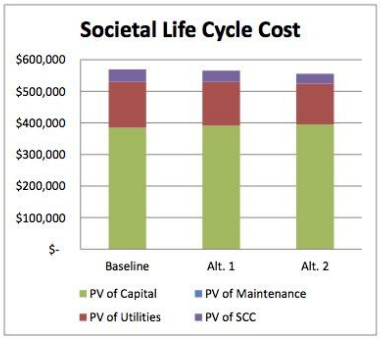
Project Information	
Project:	OR 2,200 SF Home: 10% and 20% Savings
Address:	123 Central Oregon St, Bend,
Company:	
Contact:	
Contact Phone:	
Contact Email:	

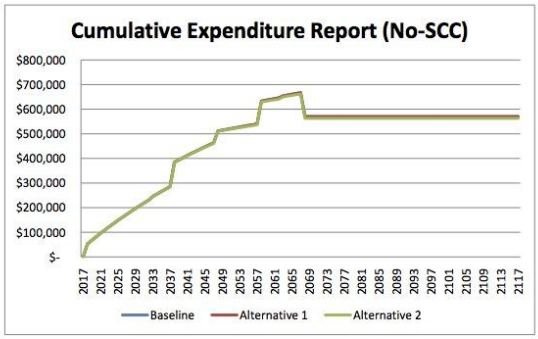
Key Analysis Variables		Building Characteristics	
Study Period (years)	51	Gross (Sq.Ft)	2,200
Nominal Discount Rate	3.46%	Useable (Sq.Ft)	2,200
Maintenance Escalation	1.00%	Space Efficiency	100.0%
Zero Year (Current Year)	2017	Project Phase	0
Construction Years	1	Building Type	0

Life Cycle Cost Analysis			BEST
Alternative	Baseline	Alt. 1	Alt. 2
Energy Use Intenstity (kBtu/sq.ft)	32.2	29.5	26.2
1st Construction Costs	$ 262,841	$ 265,665	$ 268,991
PV of Capital Costs	$ 384,499	$ 391,262	$ 395,289
PV of Maintenance Costs	$ -	$ -	$ -
PV of Utility Costs	$ 145,920	$ 138,232	$ 128,611
Total Life Cycle Cost (LCC)	**$ 530,420**	**$ 529,494**	**$ 523,900**
Net Present Savings (NPS)	**N/A**	**$ 925**	**$ 6,520**

Societal LCC takes into consideration the social cost of carbon dioxide emissions caused by operational energy consumption

(GHG) Social Life Cycle Cost			BEST
GHG Impact from Utility Consumption	Baseline	Alt. 1	Alt. 2
Tons of CO2e over Study Period	436	400	354
% CO2e Reduction vs. Baseline	N/A	8%	20%
Present Social Cost of Carbon (SCC)	$ 38,982	$ 35,739	$ 31,681
Total LCC with SCC	**$ 569,402**	**$ 565,234**	**$ 555,581**
NPS with SCC	**N/A**	**$ 4,168**	**$ 13,821**





Baseline Short Description
Single Family Construction with cost of $120/sf
Alternative 1 Short Description
10% better than code with Elec Heat, 1.1% cost premium
Alternative 2 Short Description
20% better than code with Elec Heat, 2.3% cost premium

Appendix C-1: LCCT Expenditure Report for Multifamily 10 percent and 20 percent Savings

Multifamily Building Expenditures: Alt 1 is 10%, Alt 2 is 20%

	Alternative 1 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline	Alternative 2 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline
Year	Capital	Maintenance	Utilities	Financing	Total	Alt. 1	Annual	Cumulative	Capital	Maintenance	Utilities	Financing	Total	Alt. 2	Cumulative	Annual
2017	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2018	$3,165,855	$0	$0	-$2,532,684	$633,171	$633,171	$7,371	$7,371	$3,253,200	$0	$0	-$2,602,560	$650,640	$650,640	$24,840	$24,840
2019	$0	$0	$0	$173,439	$173,439	$806,610	$2,019	$9,390	$0	$0	$0	$178,224	$178,224	$828,864	$6,804	$31,644
2020	$0	$0	$61,985	$168,225	$230,211	$1,036,820	-$7,934	$1,456	$0	$0	$56,143	$172,867	$229,010	$1,057,874	-$9,135	$22,509
2021	$0	$0	$62,248	$163,169	$225,416	$1,262,237	-$8,021	-$6,565	$0	$0	$56,417	$167,670	$224,088	$1,281,961	-$9,350	$13,160
2022	$0	$0	$62,248	$158,264	$220,512	$1,482,748	-$8,078	-$14,643	$0	$0	$56,464	$162,630	$219,095	$1,501,056	-$9,495	$3,665
2023	$0	$0	$62,248	$153,506	$215,754	$1,698,503	-$8,133	-$22,776	$0	$0	$56,512	$157,742	$214,253	$1,715,309	-$9,634	-$5,970
2024	$0	$0	$61,985	$148,892	$210,877	$1,909,380	-$8,159	-$30,936	$0	$0	$56,355	$153,000	$209,355	$1,924,665	-$9,681	-$15,651
2025	$0	$0	$62,248	$144,416	$206,664	$2,116,044	-$8,239	-$39,175	$0	$0	$56,606	$148,401	$205,007	$2,129,672	-$9,897	-$25,547
2026	$0	$0	$62,248	$140,075	$202,323	$2,318,367	-$8,290	-$47,465	$0	$0	$56,653	$143,940	$200,593	$2,330,265	-$10,020	-$35,567
2027	$0	$0	$62,248	$135,865	$198,112	$2,516,479	-$8,339	-$55,803	$0	$0	$56,677	$139,613	$196,290	$2,526,555	-$10,161	-$45,728
2028	$0	$0	$62,248	$131,781	$194,028	$2,710,508	-$8,386	-$64,190	$0	$0	$56,653	$135,416	$192,070	$2,718,624	-$10,345	-$56,073
2029	$0	$0	$61,985	$127,819	$189,804	$2,900,312	-$8,404	-$72,594	$0	$0	$56,450	$131,346	$187,796	$2,906,420	-$10,413	-$66,486
2030	$0	$0	$61,985	$123,977	$185,962	$3,086,274	-$8,449	-$81,043	$0	$0	$56,473	$127,398	$183,871	$3,090,291	-$10,540	-$77,027
2031	$0	$0	$61,985	$120,250	$182,235	$3,268,510	-$8,493	-$89,536	$0	$0	$56,497	$123,568	$180,065	$3,270,356	-$10,663	-$87,690
2032	$0	$0	$61,985	$116,636	$178,621	$3,447,131	-$8,535	-$98,071	$0	$0	$56,544	$119,854	$176,398	$3,446,754	-$10,758	-$98,447
2033	$0	$0	$61,985	$113,130	$175,115	$3,622,245	-$8,575	-$106,646	$0	$0	$56,568	$116,251	$172,819	$3,619,573	-$10,872	-$109,319
2034	$88,000	$0	$61,985	$109,729	$259,714	$3,881,959	-$8,615	-$115,261	$141,020	$0	$56,615	$112,756	$310,391	$3,929,964	$42,062	-$67,257
2035	$0	$0	$61,985	$106,430	$168,416	$4,050,375	-$8,653	-$123,915	$0	$0	$56,662	$109,367	$166,029	$4,095,993	-$11,040	-$78,297
2036	$0	$0	$61,985	$103,231	$165,216	$4,215,592	-$8,691	-$132,605	$0	$0	$56,709	$106,079	$162,789	$4,258,782	-$11,118	-$89,415
2037	$0	$0	$62,248	$100,128	$162,376	$4,377,967	-$8,755	-$141,360	$0	$0	$56,937	$102,891	$159,827	$4,418,609	-$11,304	-$100,719
2038	$0	$0	$62,248	$97,118	$159,366	$4,537,334	-$8,790	-$150,150	$0	$0	$56,984	$99,798	$156,782	$4,575,391	-$11,374	-$112,093
2039	$762,000	$0	$62,510	$0	$824,510	$5,361,844	-$9,948	-$160,098	$764,686	$0	$57,258	$0	$821,944	$5,397,335	-$12,515	-$124,608
2040	$0	$0	$62,773	$0	$62,773	$5,424,617	-$9,976	-$170,075	$0	$0	$57,509	$0	$57,509	$5,454,844	-$15,241	-$139,848
2041	$0	$0	$62,773	$0	$62,773	$5,487,390	-$9,976	-$180,051	$0	$0	$57,556	$0	$57,556	$5,512,400	-$15,193	-$155,042
2042	$0	$0	$62,773	$0	$62,773	$5,550,163	-$9,976	-$190,028	$0	$0	$57,603	$0	$57,603	$5,570,003	-$15,146	-$170,188
2043	$0	$0	$62,773	$0	$62,773	$5,612,936	-$9,976	-$200,004	$0	$0	$57,650	$0	$57,650	$5,627,653	-$15,099	-$185,287
2044	$0	$0	$62,773	$0	$62,773	$5,675,709	-$9,976	-$209,980	$0	$0	$57,698	$0	$57,698	$5,685,351	-$15,052	-$200,339
2045	$0	$0	$62,773	$0	$62,773	$5,738,482	-$9,976	-$219,957	$0	$0	$57,745	$0	$57,745	$5,743,095	-$15,005	-$215,343
2046	$0	$0	$62,773	$0	$62,773	$5,801,255	-$9,976	-$229,933	$0	$0	$57,792	$0	$57,792	$5,800,887	-$14,957	-$230,301
2047	$0	$0	$62,773	$0	$62,773	$5,864,028	-$9,976	-$239,909	$0	$0	$57,839	$0	$57,839	$5,858,727	-$14,910	-$245,211
2048	$0	$0	$62,773	$0	$62,773	$5,926,801	-$9,976	-$249,886	$0	$0	$57,886	$0	$57,886	$5,916,613	-$14,863	-$260,074
2049	$372,400	$0	$62,773	$0	$435,173	$6,361,974	-$5,576	-$255,462	$429,820	$0	$57,934	$0	$487,754	$6,404,367	$47,004	-$213,069
2050	$0	$0	$62,773	$0	$62,773	$6,424,747	-$9,976	-$265,439	$0	$0	$57,981	$0	$57,981	$6,462,347	-$14,769	-$227,838
2051	$0	$0	$62,773	$0	$62,773	$6,487,520	-$9,976	-$275,415	$0	$0	$58,028	$0	$58,028	$6,520,376	-$14,721	-$242,559
2052	$0	$0	$62,773	$0	$62,773	$6,550,293	-$9,976	-$285,391	$0	$0	$58,075	$0	$58,075	$6,578,451	-$14,674	-$257,233
2053	$0	$0	$62,773	$0	$62,773	$6,613,066	-$9,976	-$295,368	$0	$0	$58,122	$0	$58,122	$6,636,573	-$14,627	-$271,860
2054	$0	$0	$62,773	$0	$62,773	$6,675,839	-$9,976	-$305,344	$0	$0	$58,170	$0	$58,170	$6,694,743	-$14,580	-$286,440
2055	$0	$0	$62,773	$0	$62,773	$6,738,612	-$9,976	-$315,320	$0	$0	$58,217	$0	$58,217	$6,752,960	-$14,533	-$300,973
2056	$0	$0	$62,773	$0	$62,773	$6,801,385	-$9,976	-$325,297	$0	$0	$58,264	$0	$58,264	$6,811,224	-$14,485	-$315,458
2057	$0	$0	$62,773	$0	$62,773	$6,864,158	-$9,976	-$335,273	$0	$0	$58,311	$0	$58,311	$6,869,535	-$14,438	-$329,896
2058	$0	$0	$62,773	$0	$62,773	$6,926,931	-$9,976	-$345,249	$0	$0	$58,358	$0	$58,358	$6,927,894	-$14,391	-$344,287
2059	$762,000	$0	$62,773	$0	$824,773	$7,751,704	-$9,976	-$355,226	$764,686	$0	$58,406	$0	$823,092	$7,750,985	-$11,657	-$355,944
2060	$0	$0	$62,773	$0	$62,773	$7,814,477	-$9,976	-$365,202	$0	$0	$58,453	$0	$58,453	$7,809,438	-$14,296	-$370,241
2061	$0	$0	$62,773	$0	$62,773	$7,877,250	-$9,976	-$375,179	$0	$0	$58,500	$0	$58,500	$7,867,938	-$14,249	-$384,490
2062	$0	$0	$62,773	$0	$62,773	$7,940,023	-$9,976	-$385,155	$0	$0	$58,547	$0	$58,547	$7,926,486	-$14,202	-$398,692
2063	$0	$0	$62,773	$0	$62,773	$8,002,796	-$9,976	-$395,131	$0	$0	$58,595	$0	$58,595	$7,985,080	-$14,155	-$412,847
2064	$88,000	$0	$62,773	$0	$150,773	$8,153,569	-$9,976	-$405,108	$141,020	$0	$58,642	$0	$199,662	$8,184,742	$38,912	-$373,935
2065	$0	$0	$62,773	$0	$62,773	$8,216,342	-$9,976	-$415,084	$0	$0	$58,689	$0	$58,689	$8,243,431	-$14,060	-$387,995
2066	$0	$0	$62,773	$0	$62,773	$8,279,115	-$9,976	-$425,060	$0	$0	$58,736	$0	$58,736	$8,302,167	-$14,013	-$402,008
2067	$0	$0	$62,773	$0	$62,773	$8,341,888	-$9,976	-$435,037	$0	$0	$58,783	$0	$58,783	$8,360,950	-$13,966	-$415,974
2068	$0	$0	$62,773	$0	$62,773	$8,404,661	-$9,976	-$445,013	$0	$0	$58,831	$0	$58,831	$8,419,781	-$13,919	-$429,893
2069	-$1,121,952	$0	$62,773	$0	-$1,059,179	$7,345,482	-$22,261	-$467,274	-$1,169,188	$0	$58,878	$0	-$1,110,310	$7,309,471	-$73,393	-$503,286

Note: Highlighted cells indicate the first year that cumulative costs are less than code baseline.

Appendix C-2: LCCT Expenditure Report for Hillsboro Gas Heat Single Family 10 percent and 20 percent Savings

Single Family Gas-Heated Home Expenditures in Hillsboro: Alt 1 is 10%, Alt 2 is 20%

	Alternative 1 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline	Alternative 2 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline
Year	Capital	Maintenance	Utilities	Financing	Total	Alt. 1	Annual	Cumulative	Capital	Maintenance	Utilities	Financing	Total	Alt. 2	Cumulative	Annual
2017	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2018	$ 264,633	$ -	$ -	-$211,706	$ 52,927	$ 52,927	$127	$127	$268,563	$0	$0	-$214,850	$53,713	$53,713	$913	$913
2019	$ -	$ -	$ 2,456	$ 11,409	$ 13,866	$ 66,792	-$159	-$32	$0	$0	$2,320	$11,579	$13,899	$67,611	-$125	$787
2020	$ -	$ -	$ 2,484	$ 11,066	$ 13,550	$ 80,342	-$161	-$193	$0	$0	$2,343	$11,231	$13,574	$81,185	-$138	$650
2021	$ -	$ -	$ 2,512	$ 10,734	$ 13,246	$ 93,588	-$165	-$358	$0	$0	$2,368	$10,893	$13,261	$94,446	-$150	$499
2022	$ -	$ -	$ 2,523	$ 10,411	$ 12,934	$ 106,522	-$167	-$525	$0	$0	$2,377	$10,566	$12,943	$107,389	-$158	$341
2023	$ -	$ -	$ 2,534	$ 10,098	$ 12,632	$ 119,155	-$168	-$693	$0	$0	$2,387	$10,248	$12,634	$120,023	-$166	$175
2024	$ -	$ -	$ 2,533	$ 9,794	$ 12,328	$ 131,483	-$168	-$861	$0	$0	$2,385	$9,940	$12,325	$132,348	-$171	$4
2025	$ -	$ -	$ 2,556	$ 9,500	$ 12,056	$ 143,539	-$171	-$1,032	$0	$0	$2,405	$9,641	$12,046	$144,394	-$181	-$177
2026	$ -	$ -	$ 2,567	$ 9,214	$ 11,782	$ 155,321	-$173	-$1,205	$0	$0	$2,414	$9,351	$11,766	$156,160	-$189	-$366
2027	$ -	$ -	$ 2,573	$ 8,937	$ 11,510	$ 166,831	-$174	-$1,379	$0	$0	$2,419	$9,070	$11,489	$167,649	-$195	-$561
2028	$ -	$ -	$ 2,567	$ 8,669	$ 11,236	$ 178,067	-$174	-$1,553	$0	$0	$2,414	$8,798	$11,212	$178,861	-$198	-$759
2029	$ -	$ -	$ 2,555	$ 8,408	$ 10,963	$ 189,031	-$173	-$1,725	$0	$0	$2,404	$8,533	$10,937	$189,798	-$200	-$959
2030	$ -	$ -	$ 2,561	$ 8,155	$ 10,716	$ 199,747	-$174	-$1,899	$0	$0	$2,408	$8,277	$10,685	$200,482	-$205	-$1,164
2031	$ -	$ -	$ 2,566	$ 7,910	$ 10,477	$ 210,224	-$175	-$2,074	$0	$0	$2,413	$8,028	$10,441	$210,923	-$211	-$1,375
2032	$ -	$ -	$ 2,577	$ 7,673	$ 10,250	$ 220,473	-$176	-$2,250	$0	$0	$2,422	$7,786	$10,209	$221,131	-$217	-$1,592
2033	$ 4,222	$ -	$ 2,583	$ 7,442	$ 14,247	$ 234,720	$45	-$2,205	$4,606	$0	$2,427	$7,552	$14,585	$235,716	$383	-$1,208
2034	$ -	$ -	$ 2,594	$ 7,218	$ 9,812	$ 244,532	-$178	-$2,383	$0	$0	$2,436	$7,325	$9,761	$245,478	-$229	-$1,437
2035	$ -	$ -	$ 2,605	$ 7,001	$ 9,606	$ 254,138	-$180	-$2,563	$0	$0	$2,445	$7,105	$9,550	$255,028	-$235	-$1,672
2036	$ -	$ -	$ 2,616	$ 6,791	$ 9,406	$ 263,544	-$181	-$2,743	$0	$0	$2,454	$6,892	$9,346	$264,374	-$241	-$1,914
2037	$ -	$ -	$ 2,633	$ 6,587	$ 9,220	$ 272,764	-$184	-$2,927	$0	$0	$2,470	$6,684	$9,154	$273,529	-$249	-$2,163
2038	$ 89,871	$ -	$ 2,644	$ 6,389	$ 98,904	$ 371,668	$186	-$2,741	$89,871	$0	$2,479	$6,484	$98,834	$372,362	$116	-$2,047
2039	$ -	$ -	$ 2,673	$ 6,197	$ 8,870	$ 380,538	-$188	-$2,929	$0	$0	$2,504	$6,289	$8,793	$381,155	-$265	-$2,312
2040	$ -	$ -	$ 2,696	$ 6,010	$ 8,706	$ 389,244	-$191	-$3,120	$0	$0	$2,524	$6,100	$8,624	$389,779	-$274	-$2,586
2041	$ -	$ -	$ 2,707	$ 5,830	$ 8,537	$ 397,781	-$192	-$3,313	$0	$0	$2,533	$5,916	$8,450	$398,228	-$280	-$2,866
2042	$ -	$ -	$ 2,718	$ 5,654	$ 8,373	$ 406,154	-$194	-$3,506	$0	$0	$2,543	$5,738	$8,281	$406,509	-$285	-$3,151
2043	$ -	$ -	$ 2,729	$ 5,484	$ 8,214	$ 414,367	-$195	-$3,701	$0	$0	$2,552	$5,566	$8,118	$414,627	-$291	-$3,441
2044	$ -	$ -	$ 2,740	$ 5,320	$ 8,060	$ 422,427	-$196	-$3,897	$0	$0	$2,561	$5,399	$7,960	$422,587	-$296	-$3,737
2045	$ -	$ -	$ 2,751	$ 5,160	$ 7,911	$ 430,338	-$197	-$4,094	$0	$0	$2,570	$5,236	$7,807	$430,393	-$301	-$4,038
2046	$ -	$ -	$ 2,762	$ 5,005	$ 7,767	$ 438,104	-$198	-$4,292	$0	$0	$2,580	$5,079	$7,659	$438,052	-$306	-$4,345
2047	$ -	$ -	$ 2,773	$ 4,854	$ 7,627	$ 445,732	-$199	-$4,492	$0	$0	$2,589	$4,926	$7,515	$445,567	-$311	-$4,656
2048	$ 39,762	$ -	$ 2,784	$ 4,708	$ 47,254	$ 492,986	$61	-$4,430	$40,546	$0	$2,598	$4,778	$47,922	$493,490	$730	-$3,927
2049	$ -	$ -	$ 2,795	$ -	$ 2,795	$ 495,781	-$213	-$4,643	$0	$0	$2,607	$0	$2,607	$496,097	-$400	-$4,327
2050	$ -	$ -	$ 2,806	$ -	$ 2,806	$ 498,587	-$213	-$4,856	$0	$0	$2,617	$0	$2,617	$498,714	-$403	-$4,729
2051	$ -	$ -	$ 2,817	$ -	$ 2,817	$ 501,404	-$214	-$5,070	$0	$0	$2,626	$0	$2,626	$501,340	-$405	-$5,134
2052	$ -	$ -	$ 2,828	$ -	$ 2,828	$ 504,232	-$215	-$5,285	$0	$0	$2,635	$0	$2,635	$503,975	-$408	-$5,542
2053	$ -	$ -	$ 2,839	$ -	$ 2,839	$ 507,071	-$216	-$5,501	$0	$0	$2,645	$0	$2,645	$506,620	-$410	-$5,952
2054	$ -	$ -	$ 2,850	$ -	$ 2,850	$ 509,921	-$216	-$5,717	$0	$0	$2,654	$0	$2,654	$509,274	-$413	-$6,365
2055	$ -	$ -	$ 2,861	$ -	$ 2,861	$ 512,782	-$217	-$5,935	$0	$0	$2,663	$0	$2,663	$511,937	-$415	-$6,780
2056	$ -	$ -	$ 2,872	$ -	$ 2,872	$ 515,654	-$218	-$6,153	$0	$0	$2,672	$0	$2,672	$514,609	-$418	-$7,197
2057	$ -	$ -	$ 2,883	$ -	$ 2,883	$ 518,537	-$219	-$6,371	$0	$0	$2,682	$0	$2,682	$517,291	-$420	-$7,618
2058	$ 89,871	$ -	$ 2,894	$ -	$ 92,765	$ 611,302	$151	-$6,220	$89,871	$0	$2,691	$0	$92,562	$609,853	-$52	-$7,669
2059	$ -	$ -	$ 2,905	$ -	$ 2,905	$ 614,207	-$220	-$6,440	$0	$0	$2,700	$0	$2,700	$612,553	-$425	-$8,094
2060	$ -	$ -	$ 2,916	$ -	$ 2,916	$ 617,123	-$221	-$6,661	$0	$0	$2,709	$0	$2,709	$615,262	-$428	-$8,522
2061	$ -	$ -	$ 2,927	$ -	$ 2,927	$ 620,050	-$222	-$6,883	$0	$0	$2,719	$0	$2,719	$617,981	-$430	-$8,952
2062	$ -	$ -	$ 2,938	$ -	$ 2,938	$ 622,988	-$223	-$7,106	$0	$0	$2,728	$0	$2,728	$620,709	-$433	-$9,384
2063	$ 4,222	$ -	$ 2,949	$ -	$ 7,171	$ 630,159	-$1	-$7,107	$4,606	$0	$2,737	$0	$7,343	$628,052	$171	-$9,213
2064	$ -	$ -	$ 2,960	$ -	$ 2,960	$ 633,118	-$224	-$7,331	$0	$0	$2,747	$0	$2,747	$630,799	-$438	-$9,651
2065	$ -	$ -	$ 2,971	$ -	$ 2,971	$ 636,089	-$225	-$7,556	$0	$0	$2,756	$0	$2,756	$633,554	-$440	-$10,091
2066	$ -	$ -	$ 2,982	$ -	$ 2,982	$ 639,071	-$226	-$7,782	$0	$0	$2,765	$0	$2,765	$636,319	-$443	-$10,534
2067	$ -	$ -	$ 2,993	$ -	$ 2,993	$ 642,064	-$226	-$8,008	$0	$0	$2,774	$0	$2,774	$639,094	-$445	-$10,979
2068	-$99,597	$0	$3,004	$0	-$96,593	$ 545,471	-$574	-$8,582	-$101,035	$0	$2,784	$0	-$98,251	$540,843	-$2,232	-$13,211

Note: Highlighted cells indicate the first year that cumulative costs are less than code baseline.

Appendix C-3: LCCT Expenditure Report for Bend Gas Heat Single Family 10 percent and 20 percent Savings

Single Family Gas-Heated Home Expenditures in Bend: Alt 1 is 10%, Alt 2 is 20%

	Alternative 1 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline	Alternative 2 Expenditure Report					Cumulative Expenditures	Expenditures over Baseline	Expenditures over Baseline
Year	Capital	Maintenance	Utilities	Financing	Total	Alt. 1	Annual	Cumulative	Capital	Maintenance	Utilities	Financing	Total	Alt. 2	Cumulative	Annual
2017	$ -	$ -	$ -	$ -	$ -	$ -	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2018	$ 265,348	$ -	$ -	-$212,278	$ **53,070**	$ 53,070	$270	$270	$268,563	$0	$0	-$214,850	$53,713	$53,713	$913	$913
2019	$ -	$ -	$ 2,651	$ 11,440	$ **14,091**	$ 67,161	-$149	$120	$0	$0	$2,462	$11,579	$14,041	$67,753	-$200	$713
2020	$ -	$ -	$ 2,688	$ 11,096	$ **13,784**	$ 80,944	-$154	-$34	$0	$0	$2,493	$11,231	$13,724	$81,477	-$214	$498
2021	$ -	$ -	$ 2,724	$ 10,763	$ **13,486**	$ 94,431	-$160	-$194	$0	$0	$2,524	$10,893	$13,417	$94,894	-$229	$270
2022	$ -	$ -	$ 2,738	$ 10,439	$ **13,177**	$ 107,608	-$163	-$356	$0	$0	$2,537	$10,566	$13,102	$107,996	-$237	$32
2023	$ -	$ -	$ 2,753	$ 10,125	$ **12,878**	$ 120,486	-$165	-$522	$0	$0	$2,549	$10,248	$12,797	$120,793	-$246	-$214
2024	$ -	$ -	$ 2,753	$ 9,821	$ **12,574**	$ 133,060	-$166	-$688	$0	$0	$2,550	$9,940	$12,489	$133,283	-$251	-$465
2025	$ -	$ -	$ 2,782	$ 9,526	$ **12,307**	$ 145,367	-$171	-$859	$0	$0	$2,574	$9,641	$12,215	$145,498	-$263	-$728
2026	$ -	$ -	$ 2,796	$ 9,239	$ **12,036**	$ 157,403	-$174	-$1,032	$0	$0	$2,587	$9,351	$11,938	$157,436	-$271	-$999
2027	$ -	$ -	$ 2,804	$ 8,962	$ **11,765**	$ 169,168	-$176	-$1,208	$0	$0	$2,593	$9,070	$11,663	$169,099	-$278	-$1,277
2028	$ -	$ -	$ 2,796	$ 8,692	$ **11,489**	$ 180,657	-$176	-$1,384	$0	$0	$2,587	$8,798	$11,384	$180,484	-$281	-$1,557
2029	$ -	$ -	$ 2,782	$ 8,431	$ **11,213**	$ 191,870	-$176	-$1,560	$0	$0	$2,575	$8,533	$11,108	$191,591	-$281	-$1,838
2030	$ -	$ -	$ 2,790	$ 8,177	$ **10,967**	$ 202,837	-$178	-$1,738	$0	$0	$2,581	$8,277	$10,857	$202,449	-$287	-$2,126
2031	$ -	$ -	$ 2,797	$ 7,932	$ **10,729**	$ 213,566	-$179	-$1,917	$0	$0	$2,587	$8,028	$10,615	$213,064	-$293	-$2,419
2032	$ -	$ -	$ 2,812	$ 7,693	$ **10,505**	$ 224,070	-$182	-$2,099	$0	$0	$2,600	$7,786	$10,386	$223,450	-$300	-$2,719
2033	$ 4,222	$ -	$ 2,819	$ 7,462	$ **14,503**	$ 238,573	$38	-$2,060	$4,606	$0	$2,606	$7,552	$14,764	$238,214	$300	-$2,419
2034	$ -	$ -	$ 2,833	$ 7,238	$ **10,071**	$ 248,644	-$186	-$2,246	$0	$0	$2,618	$7,325	$9,944	$248,158	-$313	-$2,732
2035	$ -	$ -	$ 2,848	$ 7,020	$ **9,868**	$ 258,512	-$188	-$2,434	$0	$0	$2,631	$7,105	$9,736	$257,894	-$320	-$3,053
2036	$ -	$ -	$ 2,863	$ 6,809	$ **9,672**	$ 268,184	-$191	-$2,625	$0	$0	$2,643	$6,892	$9,535	$267,429	-$327	-$3,380
2037	$ -	$ -	$ 2,884	$ 6,604	$ **9,488**	$ 277,672	-$194	-$2,819	$0	$0	$2,662	$6,684	$9,346	$276,775	-$336	-$3,716
2038	$ 89,871	$ -	$ 2,898	$ 6,406	$ **99,175**	$ 376,847	$175	-$2,644	$89,871	$0	$2,674	$6,484	$99,029	$375,804	$28	-$3,688
2039	$ -	$ -	$ 2,934	$ 6,213	$ **9,148**	$ 385,995	-$201	-$2,846	$0	$0	$2,705	$6,289	$8,994	$384,798	-$355	-$4,042
2040	$ -	$ -	$ 2,963	$ 6,027	$ **8,989**	$ 394,984	-$205	-$3,051	$0	$0	$2,730	$6,100	$8,830	$393,628	-$365	-$4,408
2041	$ -	$ -	$ 2,977	$ 5,845	$ **8,823**	$ 403,807	-$208	-$3,259	$0	$0	$2,743	$5,916	$8,659	$402,287	-$372	-$4,779
2042	$ -	$ -	$ 2,992	$ 5,670	$ **8,662**	$ 412,469	-$210	-$3,468	$0	$0	$2,755	$5,738	$8,493	$410,780	-$378	-$5,157
2043	$ -	$ -	$ 3,007	$ 5,499	$ **8,506**	$ 420,975	-$212	-$3,680	$0	$0	$2,768	$5,566	$8,333	$419,114	-$384	-$5,541
2044	$ -	$ -	$ 3,021	$ 5,334	$ **8,355**	$ 429,330	-$214	-$3,894	$0	$0	$2,780	$5,399	$8,179	$427,292	-$390	-$5,931
2045	$ -	$ -	$ 3,036	$ 5,174	$ **8,209**	$ 437,539	-$216	-$4,109	$0	$0	$2,793	$5,236	$8,029	$435,321	-$396	-$6,327
2046	$ -	$ -	$ 3,050	$ 5,018	$ **8,068**	$ 445,608	-$218	-$4,327	$0	$0	$2,805	$5,079	$7,884	$443,205	-$402	-$6,729
2047	$ -	$ -	$ 3,065	$ 4,867	$ **7,932**	$ 453,540	-$220	-$4,547	$0	$0	$2,818	$4,926	$7,744	$450,949	-$408	-$7,137
2048	$ 39,762	$ -	$ 3,079	$ 4,721	$ **47,562**	$ 501,102	$40	-$4,506	$40,546	$0	$2,830	$4,778	$48,154	$499,103	$632	-$6,505
2049	$ -	$ -	$ 3,094	$ -	$ **3,094**	$ 504,196	-$247	-$4,753	$0	$0	$2,843	$0	$2,843	$501,946	-$498	-$7,003
2050	$ -	$ -	$ 3,109	$ -	$ **3,109**	$ 507,305	-$248	-$5,001	$0	$0	$2,855	$0	$2,855	$504,801	-$501	-$7,505
2051	$ -	$ -	$ 3,123	$ -	$ **3,123**	$ 510,428	-$249	-$5,251	$0	$0	$2,868	$0	$2,868	$507,669	-$505	-$8,009
2052	$ -	$ -	$ 3,138	$ -	$ **3,138**	$ 513,566	-$250	-$5,501	$0	$0	$2,880	$0	$2,880	$510,549	-$508	-$8,517
2053	$ -	$ -	$ 3,152	$ -	$ **3,152**	$ 516,718	-$252	-$5,753	$0	$0	$2,893	$0	$2,893	$513,442	-$511	-$9,029
2054	$ -	$ -	$ 3,167	$ -	$ **3,167**	$ 519,885	-$253	-$6,006	$0	$0	$2,905	$0	$2,905	$516,347	-$515	-$9,543
2055	$ -	$ -	$ 3,181	$ -	$ **3,181**	$ 523,066	-$254	-$6,260	$0	$0	$2,918	$0	$2,918	$519,265	-$518	-$10,061
2056	$ -	$ -	$ 3,196	$ -	$ **3,196**	$ 526,262	-$255	-$6,515	$0	$0	$2,930	$0	$2,930	$522,195	-$521	-$10,582
2057	$ -	$ -	$ 3,211	$ -	$ **3,211**	$ 529,473	-$257	-$6,772	$0	$0	$2,943	$0	$2,943	$525,138	-$524	-$11,106
2058	$ 89,871	$ -	$ 3,225	$ -	$ **93,096**	$ 622,569	$113	-$6,658	$89,871	$0	$2,955	$0	$92,826	$617,965	-$157	-$11,263
2059	$ -	$ -	$ 3,240	$ -	$ **3,240**	$ 625,809	-$259	-$6,917	$0	$0	$2,968	$0	$2,968	$620,932	-$531	-$11,794
2060	$ -	$ -	$ 3,254	$ -	$ **3,254**	$ 629,063	-$260	-$7,177	$0	$0	$2,980	$0	$2,980	$623,913	-$534	-$12,328
2061	$ -	$ -	$ 3,269	$ -	$ **3,269**	$ 632,332	-$261	-$7,439	$0	$0	$2,993	$0	$2,993	$626,906	-$537	-$12,865
2062	$ -	$ -	$ 3,283	$ -	$ **3,283**	$ 635,616	-$263	-$7,701	$0	$0	$3,005	$0	$3,005	$629,911	-$541	-$13,406
2063	$ 4,222	$ -	$ 3,298	$ -	$ **7,520**	$ 643,136	-$42	-$7,743	$4,606	$0	$3,018	$0	$7,624	$637,535	$62	-$13,344
2064	$ -	$ -	$ 3,313	$ -	$ **3,313**	$ 646,449	-$265	-$8,008	$0	$0	$3,030	$0	$3,030	$640,565	-$547	-$13,891
2065	$ -	$ -	$ 3,327	$ -	$ **3,327**	$ 649,776	-$266	-$8,274	$0	$0	$3,043	$0	$3,043	$643,608	-$550	-$14,442
2066	$ -	$ -	$ 3,342	$ -	$ **3,342**	$ 653,118	-$267	-$8,542	$0	$0	$3,055	$0	$3,055	$646,664	-$554	-$14,996
2067	$ -	$ -	$ 3,356	$ -	$ **3,356**	$ 656,474	-$269	-$8,810	$0	$0	$3,068	$0	$3,068	$649,732	-$557	-$15,553
2068	-$99,835	$0	$3,371	$0	**-$96,464**	$ 560,010	-$855	-$9,665	-$101,035	$0	$3,080	$0	-$97,954	$551,777	-$2,345	-$17,898

Note: Highlighted cells indicate the first year that cumulative costs are less than code baseline.