

RESIDENTIAL CONSTRUCTION COST ANALYSIS

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LIST OF ABBREVIATIONS

Abbreviation	Definition
ACH	Air Changes per Hour
BTU	British Thermal Unit
CO2	Carbon Dioxide
CSG	Community Solar Garden
DHW	Domestic Hot Water
ECO	Energy Conservation Opportunity
ECM	Energy Conservation Measure (synonymous to ECO)
EUI	Energy Utilization Index
ERV	Energy Recovery Ventilator
EV	Electric Vehicle
F	Fahrenheit
FCU	Fan Coil Unit
FY	Fiscal Year
HERS	Home Energy Rating System
HSPF	Heating Seasonal Performance Factor
HVAC	Heating, Ventilation, and Air-Conditioning
HW	Hot Water
IECC	International Energy Conservation Code
IWG	Inches of Water Gauge
kBtu	Thousand British Thermal Units
kW	Kilowatt/Thousand Watts
kWh	Kilowatt Hour
PNNL	Pacific Northwest National Laboratory
PV	Photovoltaic
SEER	Seasonal Energy Efficiency Ratio
SCC	Social Cost of Carbon
Sq. Ft., SF	Square Foot
TBD	To Be Determined
UEF	Uniform Energy Factor

1 INTRODUCTION

1.1 Executive Summary

Group14's scope for this report is to evaluate the first costs of the City of Louisville's codes as compared to a 2018 IECC baseline home for the 550 homes lost in the Marshall Fires on December 30, 2021. The size of the average home lost was 2,820 SF with 4 bedrooms and 3 bathrooms. Homeowners are under-insured to rebuild their homes – estimated on a scale of \$100,000-\$500,000. The City is hoping to determine the cost feasibility of designing new homes to the current codes.

Working with two local home builders and the Pacific Northwest National Laboratory (PNNL), Group14 has collected cost data for the upgrades to comply with different iterations of the code:

1. 2021 IECC unamended
2. 2021 IECC as amended by City of Louisville, excluding Appendix RC: natural gas compliance approach
3. 2021 IECC as amended by City of Louisville, excluding Appendix RC: all-electric compliance approach
4. 2021 IECC as amended by City of Louisville, including Appendix RC: natural gas compliance approach
5. 2021 IECC as amended by City of Louisville, including Appendix RC: all-electric approach

Our findings show that the upgrades to the different code iterations will incur additional first costs for the homeowners. The 2021 IECC (unamended) is estimated to cost \$6,450 and the 2021 IECC as amended will cost an estimated \$9,000-\$22,000 per home.

Xcel Energy has committed to providing funds to relieve the increased first cost for homeowners. These funds are as follows:

- \$7,500 per home rebuilding in a jurisdiction subject to the 2021 IECC energy code
- Additional incentives for compliance with Energy Star v3.2, Zero Energy Ready Homes v2, Energy Star New Certification Program, and Passive House Standards. These additional incentives are additive to the 2021 IECC energy code incentive, however these standards will require additional first costs that are not included in the scope of this report.

The governor has issued a letter stating that it is the intent at the state level to provide additional funding for homeowners devastated by the fires, as well.

It is the city's goal to make the energy codes equitable and affordable for all new construction homes, not just those impacted by the fires. Therefore, future work for this task may include recommendations to optimize the City's residential amendments to further reduce first costs for homeowners while increasing annual energy savings.

2 CODE EVALUATION

The City of Louisville has adopted the 2021 IECC residential provisions for new construction residential homes. The appendix includes the specific envelope, lighting, HVAC, electric infrastructure, renewable energy, and plumbing upgrades included in the cost evaluation.

Most homes lost in the Marshall Fire were built in the early 1990's. The International Code Council and US Department of Energy estimates that the 2021 IECC provides a 51% annual energy use reduction as compared to the predominate energy codes in the early 1990s. The 2021 IECC provides an average estimated 9% annual energy savings over the 2018 IECC.

The City of Louisville has amended the 2021 IECC to include many energy savings measures for residential new construction. In addition to these amendments, Louisville has adopted Appendix RC of the 2021 IECC as mandatory. The City has been advised to amend Appendix RC to require a HERS score of 47 and a HERS score of 0. The remainder of this report will assume that this amendment will be passed.

To comply with the required HERS score of 0, homeowners will need to provide either a combination of on-site solar with off-site solar or, alternatively, all off-site solar through a Community Solar Garden (CSG) to offset the energy use of their home. The first costs and annual energy cost implications of both of these pathways are discussed in Section 3.2 of this report.

To comply with the HERS score of 47, homeowners will need to provide more efficient mechanical and plumbing equipment, as well as seal their homes to a level above what is required by the 2021 IECC. Two paths have been identified to get a typical home to a HERS score of 47: an all-electric path and a natural gas heating path. In addition to the increase in energy efficiency of the mechanical and plumbing systems, photovoltaics (either on-site or off-site) will be required. The lowest first-cost path will be for homeowners to buy into solar gardens. Solar gardens do not provide the same cost savings as an on-site solar PV system does; however, the current bill credit provided by Xcel Energy offsets the cost of electricity generation. The City has confirmed that there will be enough capacity in the state for all 550 homes being rebuilt to buy into solar gardens.

Multiple Community Solar Gardens in the State have affirmed their commitment to reducing the cost to buy into solar gardens for those impacted by the fires. This would further reduce the annual energy costs for homes purchasing electricity through the Community Solar Gardens.

3 FIRST COST IMPACTS

3.1 National and Regional Estimates

Pacific Northwest National Laboratory (PNNL) published a study in February 2022, prepared for the US Department of Energy, which evaluates the cost implications of the additional energy efficiency measures for the 2021 IECC as compared to the 2018 IECC for Louisville, CO.

The first cost estimates in this report are a maximum of \$3,000 less than the first cost estimates provided by our home builder partners. This supports pricing included in this report.

3.2 Local Estimates

Two home builders familiar with the local codes have provided pricing for four different new home options based off the average home size lost in the fire. These home builders have similar findings which are summarized below. The cost upgrades are listed as an average total upgrade for each option. Itemized cost breakouts are included in the appendix to this report.

The following table shows only the most affordable, first cost upgrade for each code iteration discussed previously. Our analysis found that the lowest first-cost option for the current codes as amended includes off-site solar. Homeowners will be able to select between complying with Appendix RC via Community Solar Gardens or a combination of on-site solar and Community Solar Garden enrollment. Tables 2 and 3 present a solar study which reflects the costs of on-site solar versus the cost of enrollment in a Community Solar Garden.

The Appendix RC compliance paths in Table 1 assume the first cost of buying into a CSG and do not include ongoing costs of the CSGs. The solar options and annual energy cost implications have been shown in Table 3. Costs have been provided by Markel and Boulder Creek Neighborhoods



CODE UPGRADE	FIRST COST OF EQUIPMENT	ANNUAL ENERGY COSTS (INCLUDING IMPACT OF CSG)	HOMEOWNER INCENTIVE FROM XCEL ENERGY	MAJOR UPGRADES INCLUDED IN FIRST COST (subsequent option shows upgrade to 2021 IECC and relevant option by fuel type)
2021 IECC	\$6,450	\$2,397	\$7,500	<ul style="list-style-type: none"> R-20 batt + R-5 ci (1" XPS) R-60 batt in attic 16 SEER cooling efficiency Energy Star appliances
2021 IECC as amended, natural gas (excl. Appendix RC)	\$12,452	\$2,345	\$7,500	<ul style="list-style-type: none"> 96% efficient natural gas furnace ERV 1 EV capable space, 1 EV ready space Electric ready infrastructure
2021 IECC as amended, all-electric (excl. Appendix RC)	\$10,907	\$2,434	\$7,500	<ul style="list-style-type: none"> SEER 16/HSPF 9.0 heat pump ERV 3.0 UEF heat pump water heater 1 EV capable space, 1 EV ready space Reduced cost for natural gas infrastructure
2021 IECC as amended, natural gas (incl. Appendix RC)	\$19,867	\$2,309	\$7,500	<ul style="list-style-type: none"> Additional air sealing 96% eff furnace, SEER 21 cooling 94% eff water heater
2021 IECC as amended, all-electric (incl. Appendix RC)	\$22,352	\$2,130	\$7,500	<ul style="list-style-type: none"> Cold climate heat pump (in lieu of gas furnace) 3.48 UEF Heat pump water heater (in lieu of gas water heater) Additional air sealing

Table 1 First Cost

Homeowners will have the opportunity to either enroll in a Community Solar Garden to reduce their HERS score to 0 or provide a combination of on-site solar with enrollment in the Community Solar Garden. The current cost to enroll in a Community Solar Garden is offset by the bill credit provided by Xcel Energy. If homeowners elect to provide a combination of on-site solar and enrollment in the Community Solar Garden, our analysis calculates that on-site solar will be paid off in a maximum of 18 years.

Our solar analysis found that in this example home, a maximum of 7 kW can be installed on the roof. Our homebuilder partners found that it would cost an average of \$4.22 per watt to install 7 kW of solar on the roof of this home (\$29,568). When combined with the current 22% federal solar credit, this first cost drops to \$23,063. Table 2 below shows the annual energy costs per year for a natural gas home, as well as the total annual energy costs for 15 years (the required length of CSG contract for compliance with Louisville's amendments). Table 3 shows the same data when assessing an all-electric home.

	Annual Energy Cost	15-year Total Energy Cost	Simple Payback
100% CSG Enrollment	\$2,309	\$34,635	-
7 kW On-site PV + CSG Enrollment	\$1,035	\$15,525	18

Table 2 Annual Energy Costs for Natural Gas Home Compliant with Current Louisville Amendments

	Annual Energy Cost	15-year Total Energy Cost	Simple Payback
100% CSG Enrollment	\$2,130	\$31,950	-
7 kW On-site PV + CSG Enrollment	\$856	\$12,840	18

Table 3 Annual Energy Costs for All-Electric Home Compliant with Current Louisville Amendments

As shown in Table 2 and 3 above, the total annual energy costs are less for an all-electric home than they are for a natural gas home.

4 COST IMPACT TO HOMEOWNERS

As the above analysis shows, for homeowners to comply with the current Louisville codes as amended including Appendix RC, they will take on a minimum first cost of approximately \$12,000 when combined with the rebate from Xcel Energy, in comparison to a home built under the 2018 IECC. With an estimated annual energy savings of approximately \$270/yr (excluding on-site solar), these costs will not be offset by reductions in annual energy costs.

We recommend considering other financial incentives to help offset the energy upgrades, such as:

- Utility rebates
- Federal tax credits, including 22% tax credit on solar property and explore whether the 25D tax credit will be reinstated.
- Reduce permitting costs for homes that pursue the more efficient energy code options.
- Consider social cost of carbon emissions for less efficient homes. Reference Denver's \$79/ton of CO₂.

Recently, we have seen a trend of including the social cost of carbon (SCC) in energy and greenhouse gas emissions analysis. The social cost of carbon is an estimate of the economic costs, or damages, of emitting one ton of carbon dioxide into the atmosphere. The goal of the social cost of carbon is to indicate how much it is worth to us today to avoid the damage that is projected for the future. The City of Denver currently estimates the social cost of carbon at \$79/ton of CO₂. For an all-electric home, the avoided SCC is estimated to be \$214 annually. Over the course of 15 years, this is \$3,210.

5 CONCLUSION

In working with home builders local to the City of Louisville, Group14 has found that the first costs of building to the new 2021 IECC as amended will incur additional first costs to homeowners. This is due to the current market for construction items and availability of building materials and equipment.

The expected cost of upgrades to meet the 2021 IECC as amended will range from \$12,000 for a natural gas home which buys into a CSG, to an estimated maximum of \$38,000 for an all-electric home with PV on-site.

To reduce the first cost for homeowners, we recommend the following:

1. Investigate potential cost reductions including:
 - a. Permitting costs
 - b. Buying building materials and equipment in bulk to reduce the first cost of these items, for example:
 - i. Cold climate heat pumps
 - ii. Heat pump water heaters
 - iii. Energy recovery ventilators
2. Work with Xcel Energy to provide relief funds based on the actual projected costs of code upgrades. Also explore incentives for EV charging stations with Xcel Energy.
3. Work with Colorado Energy Office to explore grants for EV charging stations.
4. Educate the City and homeowners on the social cost of carbon and projected future cost savings



6 APPENDIX

	2018 IECC (as amended)	2021 IECC	Builder #1 Estimate	Builder #2 Estimate
Wall Insulation	R-21 batt in wood framing	R-21 batt in wood framing + R-5 ci	\$3,600	\$3,600
Roof Insulation	R-49 batt in attic	R-60 batt in attic	\$1,800	\$1,300
Floor Insulation	R-38 batt in cavity	R-30 batt in cavity	-\$400	-\$400
Basement Wall Insulation	R-19 batt in cavity	R-19 batt in cavity	\$0	\$0
HVAC system	90% eff gas furnace with 14 SEER split condensing unit	90% eff gas furnace with 16 SEER split condensing unit	\$1,700	\$1,700
Ventilation system	Mechanical	Mechanical	\$0	\$0
DHW system	80% eff water heater	80% eff water heater	\$0	\$0
Blower Door Test	3 ACH @ 0.2 IWG	3 ACH @ 0.2 IWG	\$0	\$0
Lighting	90% high efficacy lamps	All high efficacy lamps	\$0	\$0
Appliances	Standard	Standard	\$0	\$0
EV Spaces	None	None	\$0	\$0
Electric Ready	None	None	\$0	\$0
PV	None	None	\$0	\$0
AVERAGES			\$6,450	



	2018 IECC (as amended)	2021 IECC + Louisville Amendments (excl. Appendix RC, natural gas solution)	Builder #1 Estimate	Builder #2 Estimate
Wall Insulation	R-21 batt in wood framing	R-21 batt in wood framing	\$0	\$0
Roof Insulation	R-49 batt in attic	R-60 batt in attic	\$1,800	\$1,300
Floor Insulation	R-38 batt in cavity	R-38 batt in cavity	\$0	\$0
Basement Wall Insulation	R-19 batt in cavity	R-21 batt in cavity	\$220	\$220
HVAC system	90% eff gas furnace with 14 SEER split condensing unit	96% eff gas furnace with 16 SEER split condensing unit	\$2,500	\$2,500
Ventilation system	Mechanical	Mechanical with ERV	\$2,340	\$2,500
DHW system	80% eff water heater	80% eff water heater	\$0	\$0
Blower Door Test	3 ACH @ 0.2 IWG	3 ACH @ 0.2 IWG	\$0	\$0
Lighting	90% high efficacy lamps	All high efficiency lamps	\$0	\$0
Appliances	Standard	Energy Star	\$420	\$500
EV Spaces	None	1 EV Ready Space, 1 EV Capable space	\$1,920	\$1,000
Electric Ready	None	All-electric infrastructure (2x200 Amp panels)	\$3,842	\$3,842
PV	None	None	\$0	\$0
AVERAGES			\$12,452	



	2018 IECC (as amended)	2021 IECC as amended (excl. Appendix RC, all-electric solution)	Builder #1 Estimate	Builder #2 Estimate
Wall Insulation	R-21 batt in wood framing	R-21 batt in wood framing	\$0	\$0
Roof Insulation	R-49 batt in attic	R-60 batt in attic	\$1,800	\$1,300
Floor Insulation	R-38 batt in cavity	R-38 batt in cavity	\$0	\$0
Basement Wall Insulation	R-19 batt in cavity	R-21 batt in cavity	\$220	\$220
HVAC system	90% eff gas furnace with 14 SEER split condensing unit	SEER 16/HSPF 9.0 HP, electric back-up coil	\$2,000	\$2,000
Ventilation system	Mechanical	Mechanical, with ERV	\$2,340	\$2,500
DHW system	80% eff water heater	HPWH 3.0 UEF	\$1,255	\$1,255
Blower Door Test	3 ACH @ 0.2 IWG	3 ACH @ 0.2 IWG	\$0	\$0
Lighting	90% high efficacy lamps	All high efficiency lamps	\$0	\$0
Appliances	Standard	All electric, Energy Star	\$420	\$500
EV Spaces	None	1 EV Ready Space, 1 EV Capable space	\$1,920	\$1,000
Electric Ready	None	All-electric infrastructure (2x200 Amp panels) - Deduct for natural gas piping	\$1,542	\$1,542
PV	None	None	\$0	\$0
AVERAGES			\$10,907	



	2018 IECC (as amended)	2021 IECC + Louisville Amendments (Natural Gas)	Builder #1 Estimate	Builder #2 Estimate
Wall Insulation	R-21 batt in wood framing	R-38 batt in wood framing	\$1,500	\$1,500
Roof Insulation	R-49 batt in attic	R-60 batt in attic	\$1,800	\$1,300
Floor Insulation	R-38 batt in cavity	R-38 batt in cavity	\$0	\$0
Basement Wall Insulation	R-19 batt in cavity	R-21 batt in cavity	\$720	\$800
HVAC system	90% eff gas furnace with 14 SEER split condensing unit	96% efficient gas furnace with SEER 21 Split	\$16,650	\$16,500
Ventilation system	Mechanical	Mechanical, with ERV	\$4,680	\$2,500
DHW system	80% eff water heater	94% efficient water heater	\$3,150	\$2,500
Blower Door Test	3 ACH @ 0.2 IWG	2 ACH @ 0.2 IWG	\$600	\$3,500
Lighting	90% high efficacy lamps	All high efficiency lamps	\$120	\$50
Appliances	Standard	Energy Star	\$420	\$500
EV Spaces	None	1 EV Ready space, 1 EV capable space	\$1,920	\$1,000
Electric Ready	None	All-electric infrastructure (2x200 Amp panels)	\$2,940	\$2,940
PV	None	Assume enrollment in Community Solar Garden	\$0	\$0
AVERAGES			\$19,867	



	2018 IECC (as amended)	2021 IECC + Louisville Amendments (All-Electric)	Builder #1 Estimate	Builder #2 Estimate
Wall Insulation	R-21 batt in wood framing	R-38 batt in wood framing	\$1,500	\$1,500
Roof Insulation	R-49 batt in attic	R-60 batt in attic	\$1,800	\$1,300
Floor Insulation	R-38 batt in cavity	R-38 batt in cavity	\$0	\$0
Basement Wall Insulation	R-19 batt in cavity	R-21 batt in cavity	\$220	\$220
HVAC system	90% eff gas furnace with 14 SEER split condensing unit	Heat pump: 20 SEER/13.0 HSPF*	\$8,325	\$8,325
Ventilation system	Mechanical	Mechanical, with ERV	\$2,340	\$2,500
DHW system	80% eff water heater	3.48 UEF Heat pump water heater**	\$3,150	\$2,500
Blower Door Test	3 ACH @ 0.2 IWG	2 ACH @ 0.2 IWG	\$600	\$3,500
Lighting	90% high efficacy lamps	All high efficacy lamps	\$0	\$0
Appliances	Standard	All electric, Energy Star	\$420	\$500
EV Spaces	None	1 EV Ready space, 1 EV capable space	\$1,920	\$1,000
Electric Ready	None	All-electric infrastructure (2x200Amp panels) - Deduct for natural gas piping	\$1,542	\$1,542
PV	None	Assume enrollment in Community Solar Garden	\$0	\$0
AVERAGES			\$22,352	