

Cost Effectiveness of Efficient Code

ICF Cost Effectiveness of the Residential Provisions of the 2021 IECC

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Speakers



Moderator

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Cost Effectiveness of the Residential Provisions of → the 2021 IECC

2/25/2022

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Agenda

- Background / Methodology
- Changes 2021 IECC
- Savings
- Costs
 - Overview
 - Specific Code Changes
- Cost Effectiveness
- Takeaways
- Q&A

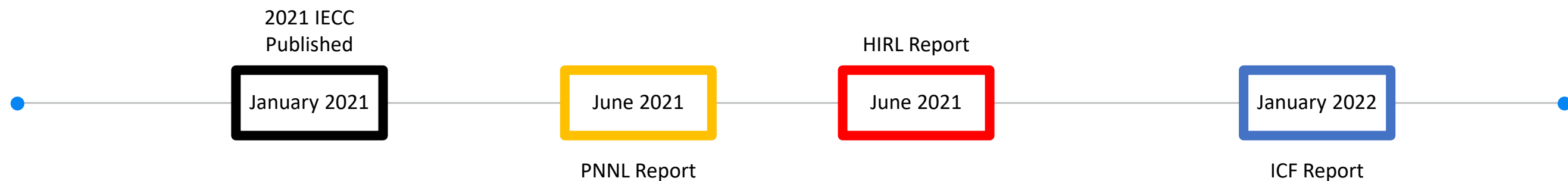


Background / Methodology

Background

- The International Code Council (ICC) updates model building codes on a 3-year cycle
- The 2021 International Energy Conservation Code (IECC) is the latest code
- DOE / PNNL determined the 2021 IECC is cost effective
- NAHB / HIRL report shows the 2021 IECC is not cost effective
- ICF reviewed NAHB / HIRL report and updated aspects of it to find a similar conclusion to DOE/PNNL

Why the different conclusions?



Methodology

- “Checking the math” of the HIRL report
 - Energy savings used directly from HIRL report, no changes made
 - Re-evaluating all code change costs
 - Determine if they result in incremental costs in practice
 - Compare costs to publicly available sources, update if necessary
 - Determine cost effectiveness
 - LCC
 - Simple payback
-
- **Note:** Purpose was to evaluate the HIRL report to have an apples-to-apples comparison. If starting from scratch ICF would have used a methodology closer to PNNL

PNNL / HIRL Methodology Differences

- There are notable differences between the HIRL and PNNL's methodologies

HIRL Methodology

6 Locations
1-3 Foundation Types
1 Fuel type
2 Wall types
20 Total Permutations
3 Bedroom 2,500 SF single-family
No multifamily

PNNL Methodology

18 Locations
4 Foundation types
4 Fuel types
1 Wall type
256 total permutations
3 Bedroom 2,376 SF single-family
2 Bedroom 1,200 SF multifamily



Changes to 2021 IECC

Envelope Improvements

- Window U-factor in CZ 3-4
- SHGC in CZ 5
- Ceiling R-values in CZ 2-8
- Continuous wall insulation in CZ 4-5
- Slab insulation in CZ 3-5

Insulation Minimum R-value and Fenestration Requirements. Source: adapted from the 2018 and 2021 IECC

Climate Zone	Fenestration U-factor	Skylight U-factor	Fenestration SHGC	Ceiling R-value	Frame Wall R-value	Mass Wall R-value	Floor R-value	Basement wall R-value*	Slab R-value & depth	Crawl Space wall R-value*
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38 <u>49</u>	13	4/6	13	0	0	0
3	0.32 <u>0.30</u>	0.55	0.25	38 <u>49</u>	20	8/13	19	5/13	10, 2 ft <u>10, 4 ft</u>	5/13
4 except Marine	0.32 <u>0.30</u>	0.55	0.40	49 <u>60</u>	20 <u>20+5</u>	8/13	19	10/13	10, 2 ft <u>10, 4 ft</u>	10/13
5 and Marine 4	0.30	0.55	NR <u>0.40</u>	49 <u>60</u>	20 <u>20+5</u>	13/17	30	15/19	10, 2 ft <u>10, 4 ft</u>	15/19
6	0.30	0.55	NR	49 <u>60</u>	20+5	15/20	30	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49 <u>60</u>	20+5	19/21	38	15/19	10, 4 ft	15/19

* Cavity insulation / continuous insulation

Systems & Lighting

- 100% high-efficacy lighting and controls
- Mechanical ventilation fan efficacy updated to ENERGY STAR v4.0 levels
- Mechanical ventilation testing required
- ERV/HRV required in CZ 7-8

Additional Efficiency Package Options

- One of five 'additional efficiency package options' must be selected

Enhanced envelope performance

- 5% improvement in building thermal envelope

More efficient HVAC equipment performance

- 95 AFUE furnace + 16 SEER AC
- 10 HSPF / 16 SEER HP

Reduced energy use in service water-heating

- 82 EF gas water heater (tankless)
- 2.0 EF electric water heater (heat pump water heater)

More efficient duct thermal distribution system

- 100% ducts in conditioned space

Improved air sealing and efficient ventilation

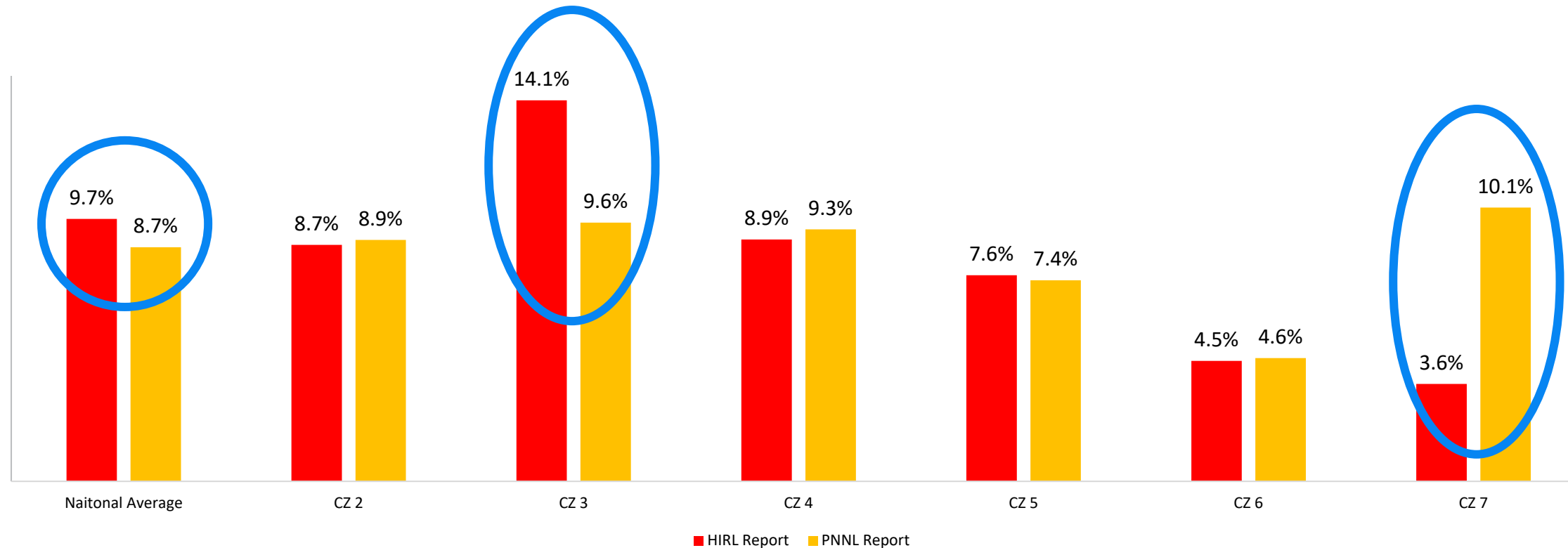
- 3.0 ACH50 and ERV/HRV



Savings

Modeled Savings Estimates

- PNNL and HIRL have general agreement in savings
 - ~9% national savings
 - ~4-10% savings in each CZ
- Significant discrepancies in CZ 3 and 7
 - Unable to determine cause,
 - Potentially differences in architecture, locations, foundation type, HVAC systems, modeling assumptions, etc.



Non-Economic Benefits

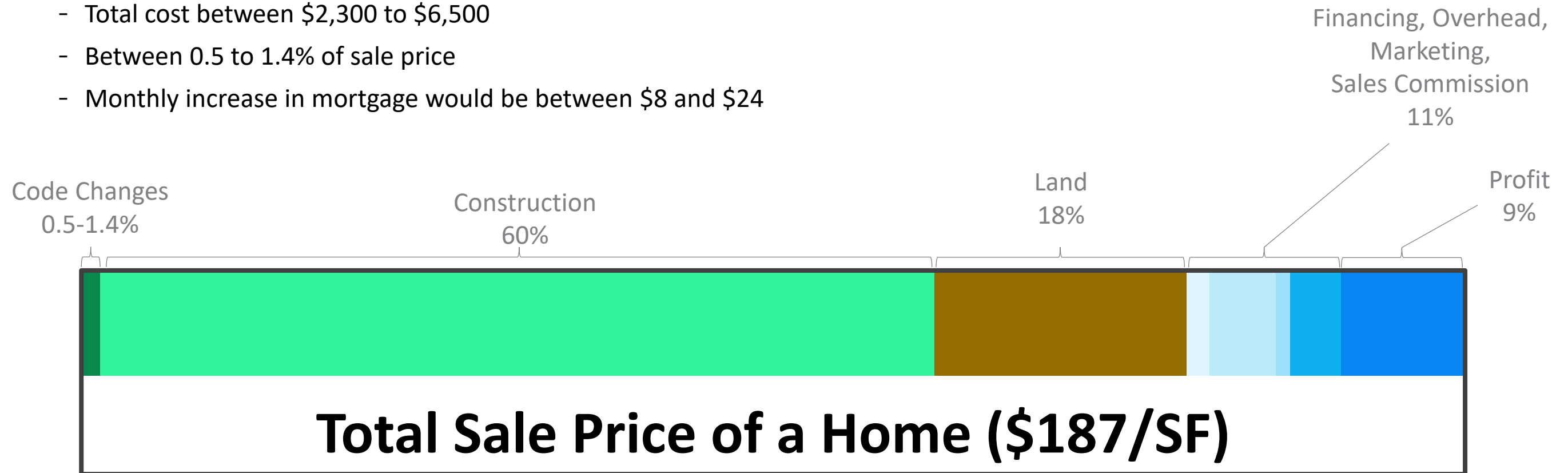
- Benefits in addition to energy cost savings that are not accounted for in cost effectiveness:
 - Emission reductions (8.66% CO₂)
 - Enhanced comfort (e.g., higher insulation, and reduced thermal bridging)
 - Improved grid reliability (e.g., reduced peak demand)
 - Increased resilience (e.g., holds temperature longer during power outages)
 - Cost savings from smaller HVAC equipment (e.g., reduced heating/cooling loads)
 - Limited opportunity for future envelope improvement
 - Never more cost-effective than at time of construction to improve efficiency



Costs

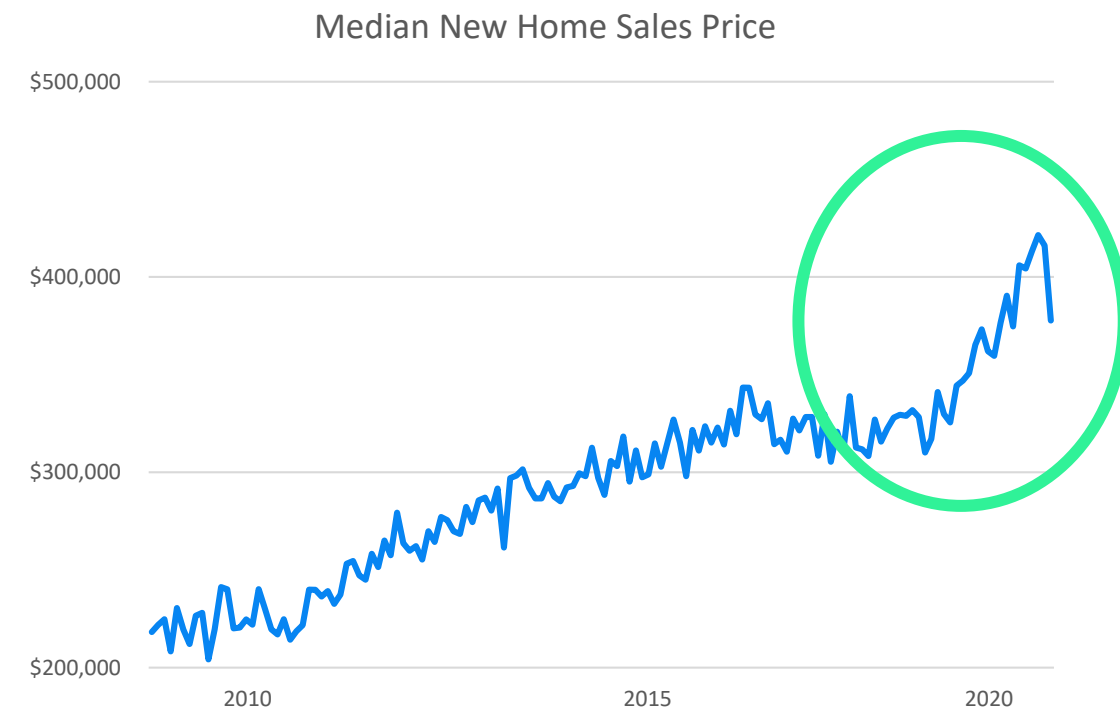
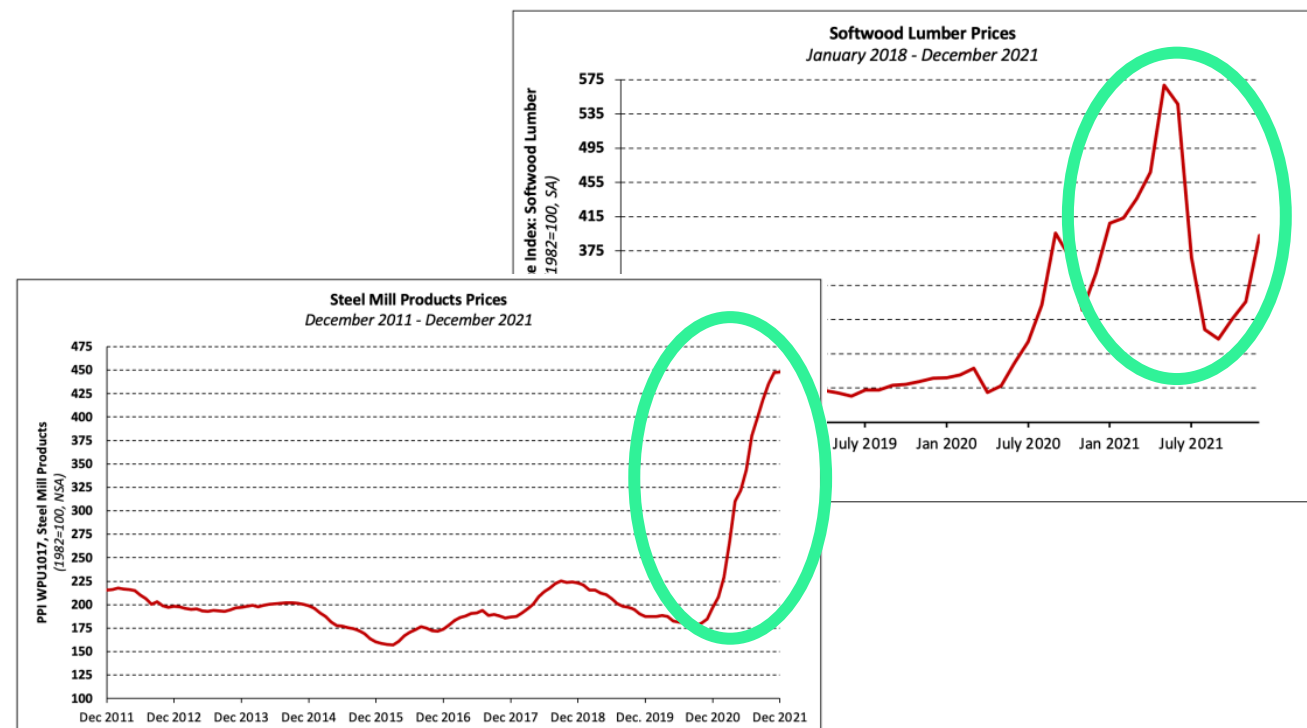
Incremental Cost in Context

- NAHB’s 2019 Construction Cost survey shows average total sale price was \$187/SF
- **Construction cost** was \$114/SF
 - Remaining costs were **Land, Financing, Overhead, Marketing, Sales Commission, and Profit** (\$73/SF)
- **Incremental Cost for 2021 IECC** is ~\$1 (ICF/PNNL) to ~\$2.50/ SF (HIRL)
 - Total cost between \$2,300 to \$6,500
 - Between 0.5 to 1.4% of sale price
 - Monthly increase in mortgage would be between \$8 and \$24



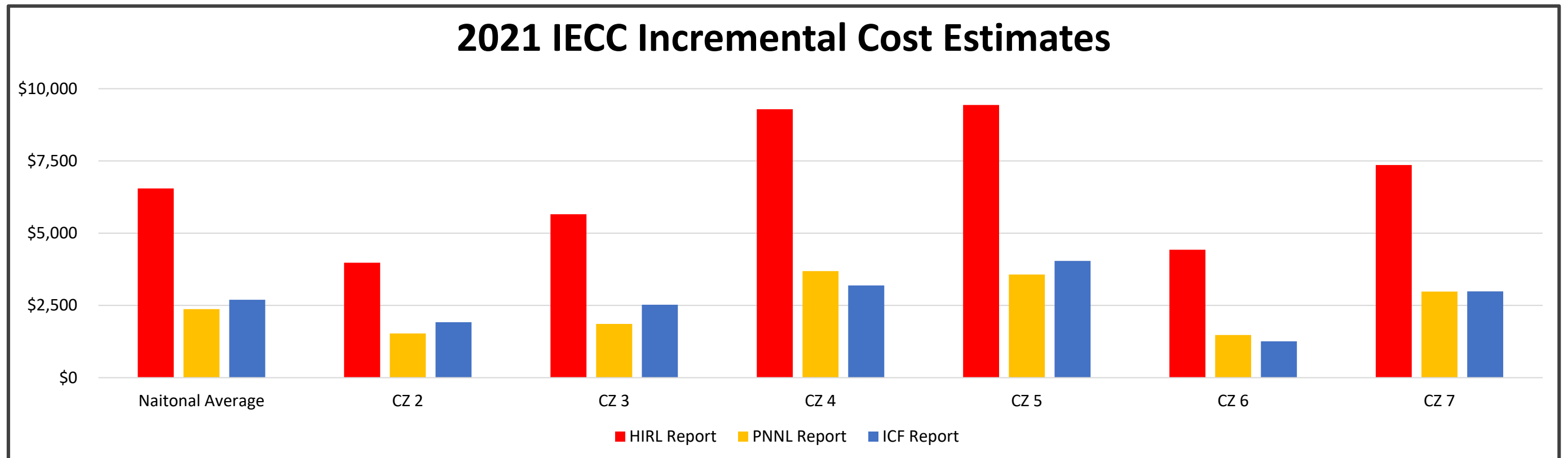
Incremental Cost in Context

- Home Prices and Construction materials have **significantly** increased in costs recently
- Housing affordability is a major issue, but...
- Increased efficiency plays a minor role in total home prices, and unlike other costs...
- Efficiency provides a regular economic return to the homeowner (reduced energy bills)

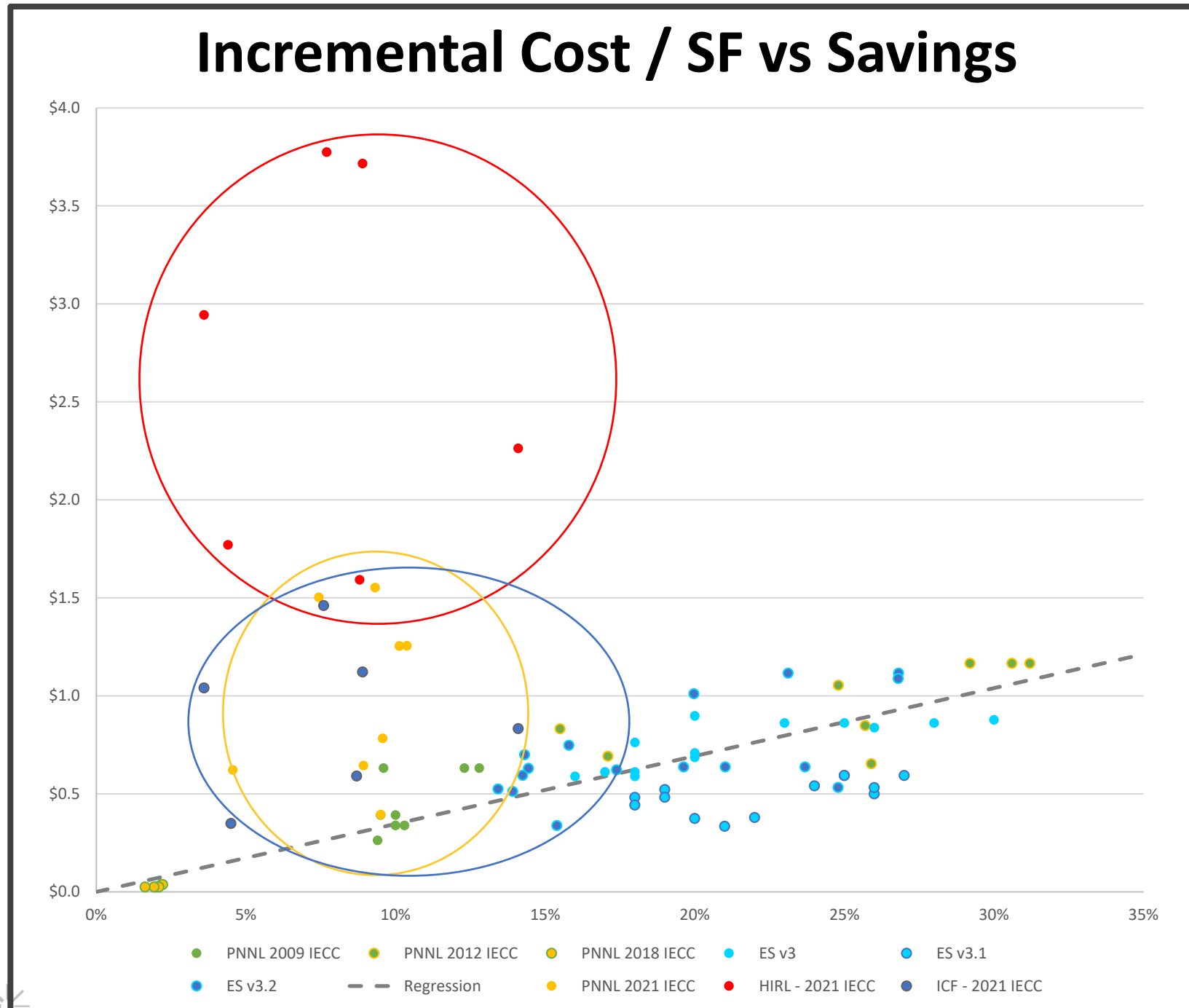


Overview of Total Incremental Costs

- HIRL estimates were significantly (2X) higher than PNNL
 - PNNL estimated ~\$2,300
 - HIRL estimated ~\$6,500
- ICF's conclusion was costs are closer to PNNL
 - ICF estimated ~\$2,700



Overview of Total Incremental Costs



- General trend in Costs vs Savings
- 2021 IECC is more expensive
 - diminishing returns
- HIRL cost estimates are outliers
- ICF estimates are in-line with other sources

Overview of Total Incremental Costs

- Consider costs discussed today:

Illustrative

- Will vary based on:
 - Current construction practices
 - Location (e.g., wage and market conditions)
 - Architectural characteristic
 - Vendor relationships (e.g., bulk purchasing power)

Conservative

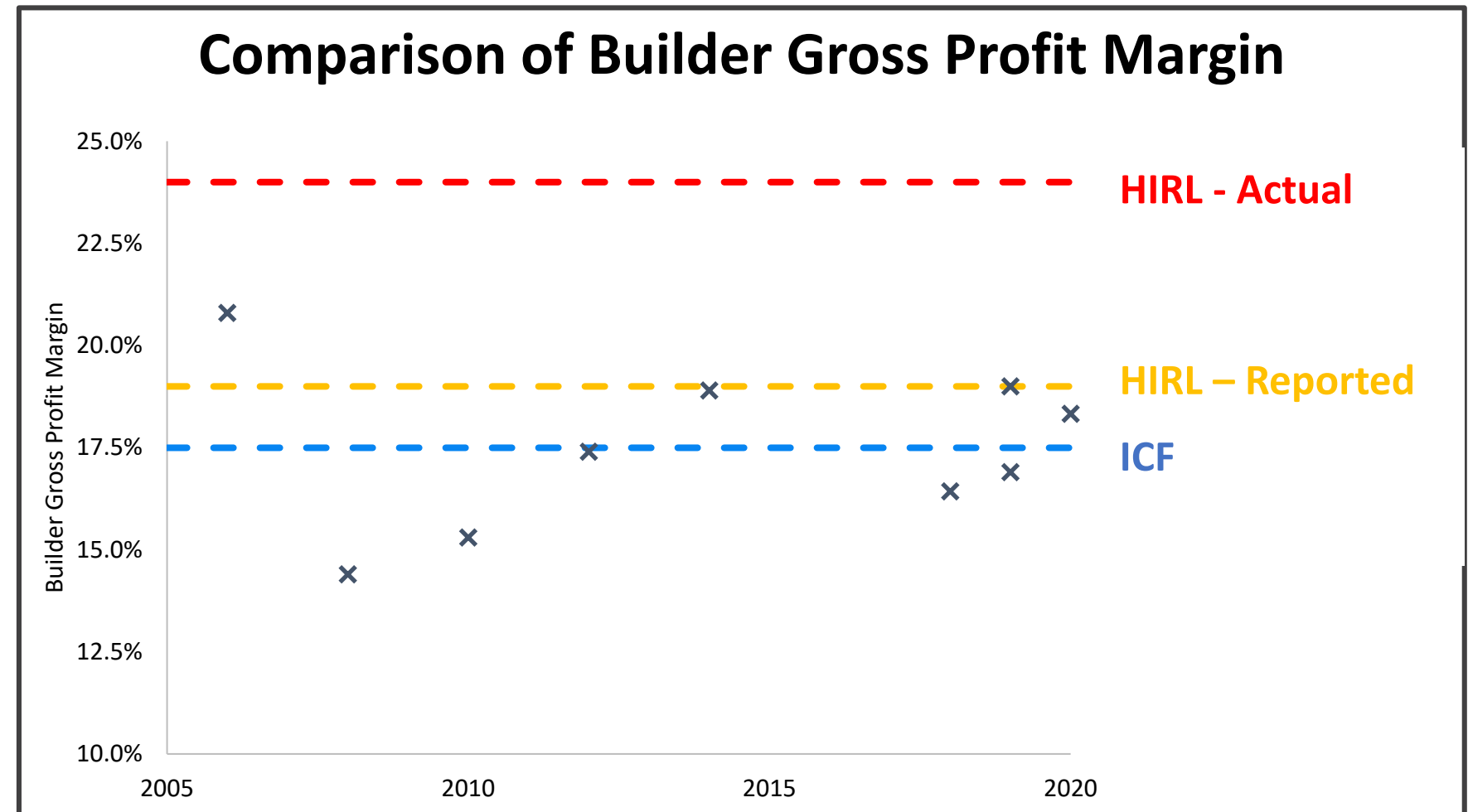
- Costs in all analysis today assume prescriptive path code compliance
- Performance and ERI paths, and UA thermal envelope alternatives in code allow more flexibility, and builders may be able to find more cost effective ways to achieve the same level of performance

Updates to HIRL Cost Estimates

- Incremental costs of the code changes reported in the HIRL report were evaluated and updated.
 - Profit margins updated
 - Some code changes revised to \$0 incremental cost
 - Material costs updated to publicly available sources
 - Labor costs generally unchanged

Profit Margins

- HIRL reported that a gross profit margin of 19% was applied to all costs
 - Based on a 2019 value, highest reported profit since 2006
- Upon review many code changes had a profit margin of 24% applied
 - Higher than any reported profit
- ICF revised to 17.5%
 - Based on an average profit over time

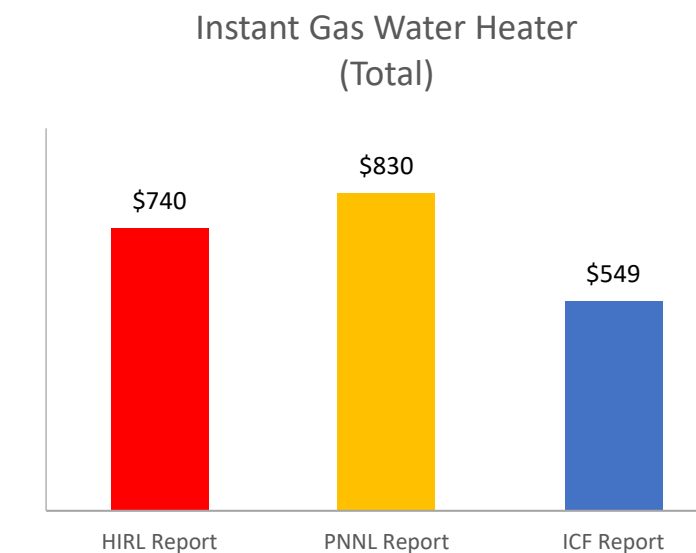
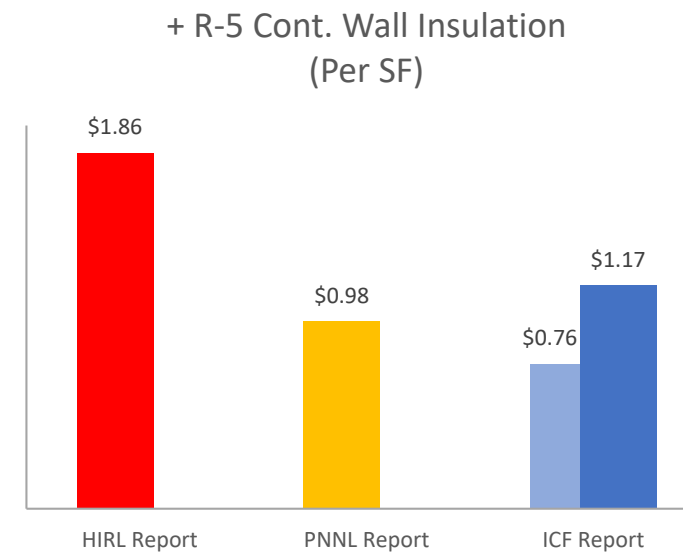
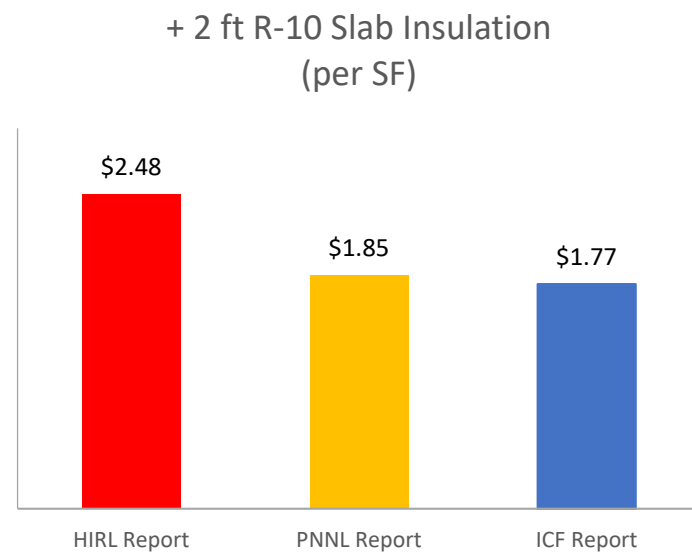
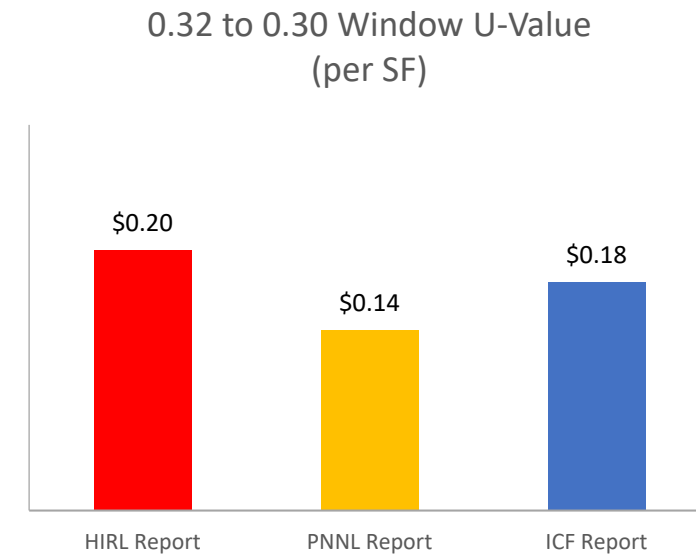
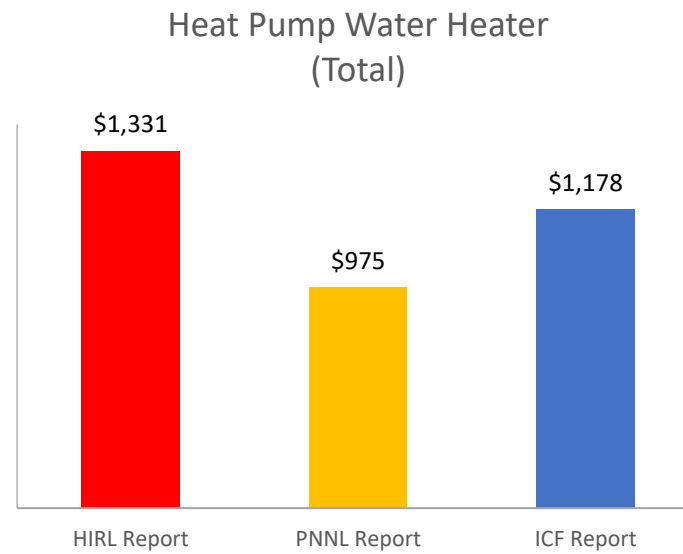
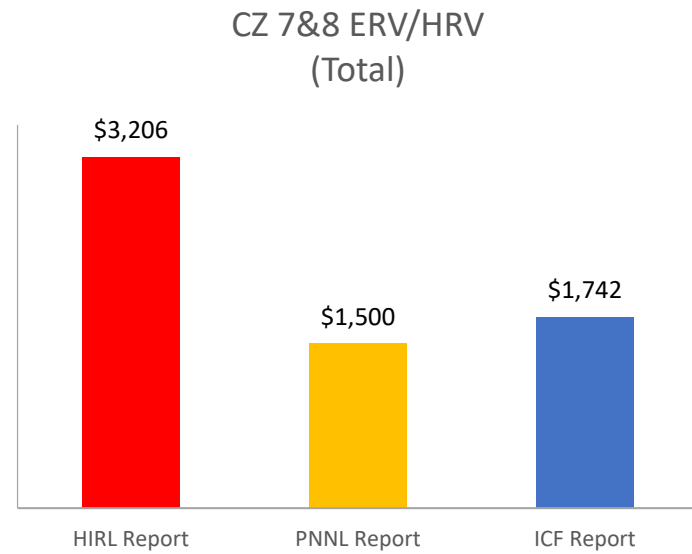


Code Changes Revised to \$0

- 6 code changes were revised to be \$0 incremental cost
 - These previously totaled \$2,376 in HIRL Report
- These code changes were determined to be:
 - Administrative with negligible incremental effort
 - Already met in practice based on existing code requirements or market conditions
 - Clarifications to existing requirements, not new requirements

Overview of Major Code Changes

- ICF's revised costs were generally lower, and closer to PNNL estimates



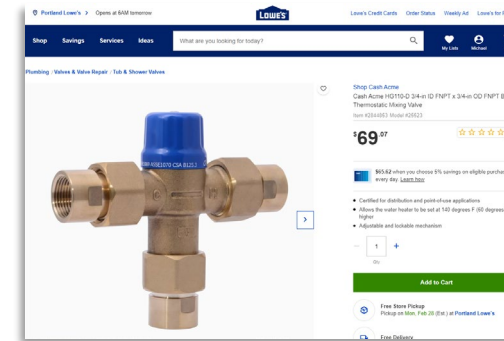
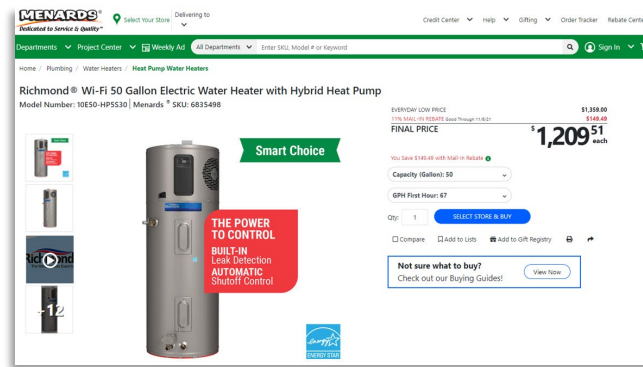
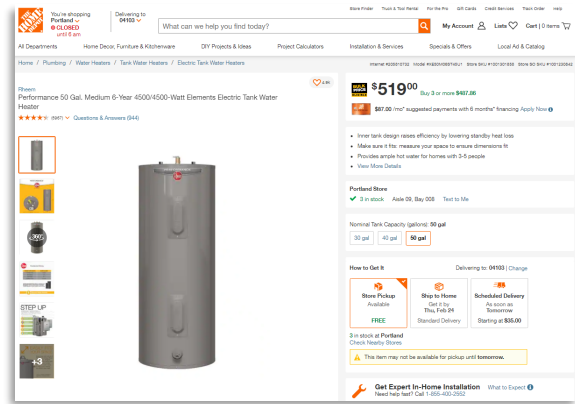
Heat Pump Water Heater Cost Example

PNNL	
Storage WH	-\$400
HPWH	+\$1375
Incremental	\$975

HIRL	
Storage WH	-\$419
HPWH	+\$1199
Mixing Valve	+\$175
Valve Labor	+\$17
Incremental	\$972
Incremental O&P	+\$359
Total Incremental	\$1,331

ICF	
Storage WH	-\$499
HPWH	+\$1359
Mixing Valve	+\$52
Valve Labor	+\$17
Incremental	\$928
Incremental O&P	+\$250
Total Incremental	\$1,178

Decrease of
 \$43 Materials
 \$109 O&P
 \$153 Total



- Material prices were sourced from major retailers / distributors in November 2021
- prices may have since changed



Cost Effectivness

Overview & Metrics

- Cost effectiveness “determine[s] whether code changes are economically justified from the perspective of a public policy that balances costs against energy savings over time” – DOE

Simple Payback

- Simple metric
- Only includes costs and benefits directly related to measures
- **HIRL only considered this**

$$\text{Payback} = (\text{First Cost}) / (\text{Annual Savings})$$

Life Cycle Cost (LCC)

- Robust cost-benefit metric that is a complete accounting of costs and benefits over time
- DOE’s primary metric
- LCC < \$0 is cost effective (i.e., benefits exceed costs)
- **ICF added this**

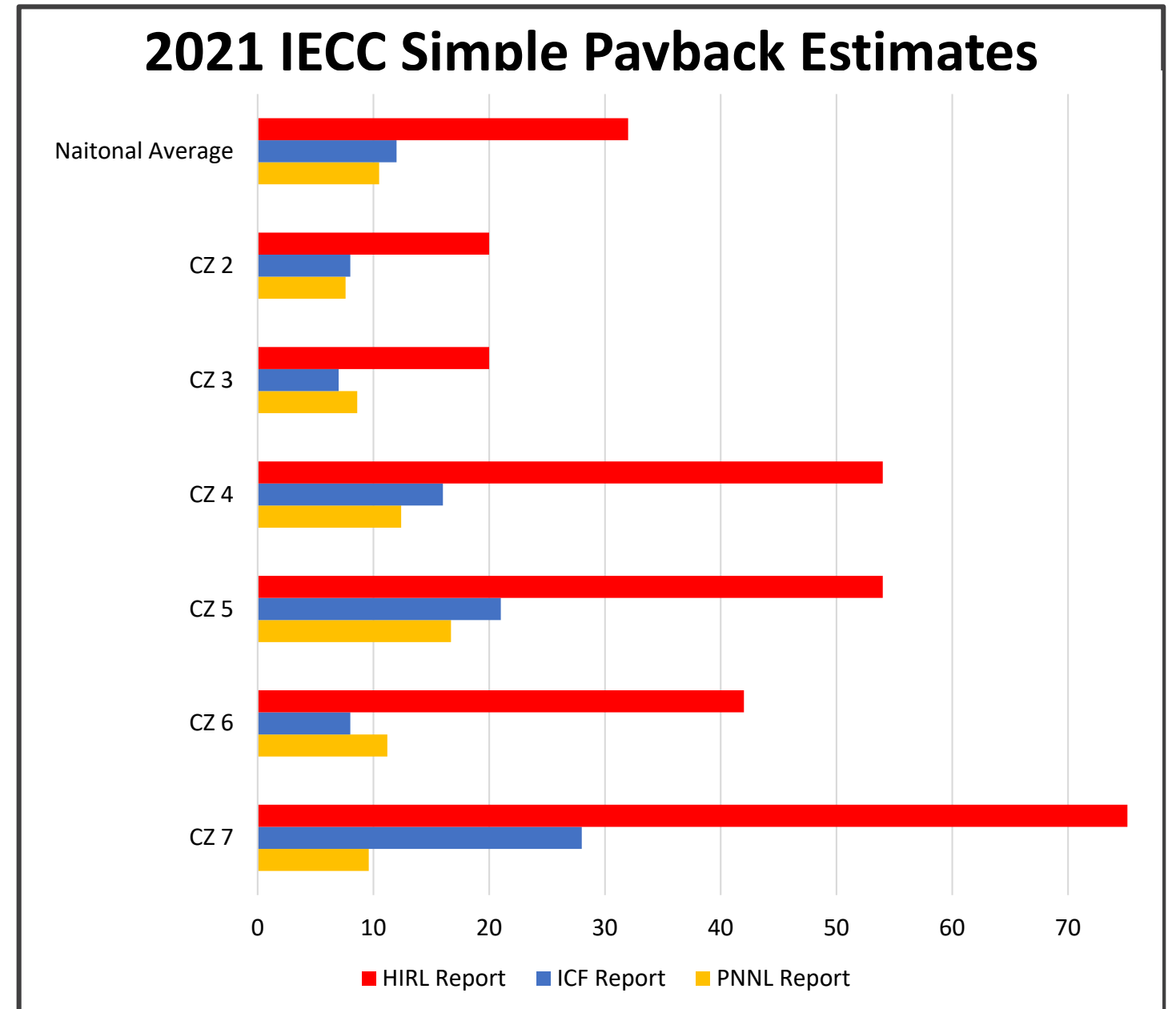
$$\text{LCC} = \text{PV} (\text{Costs}) - \text{PV} (\text{Benefits})$$

Costs = down payment + mortgage fee + property tax + mortgage payment + replacement costs

Benefits = energy savings + tax deduction + residual value

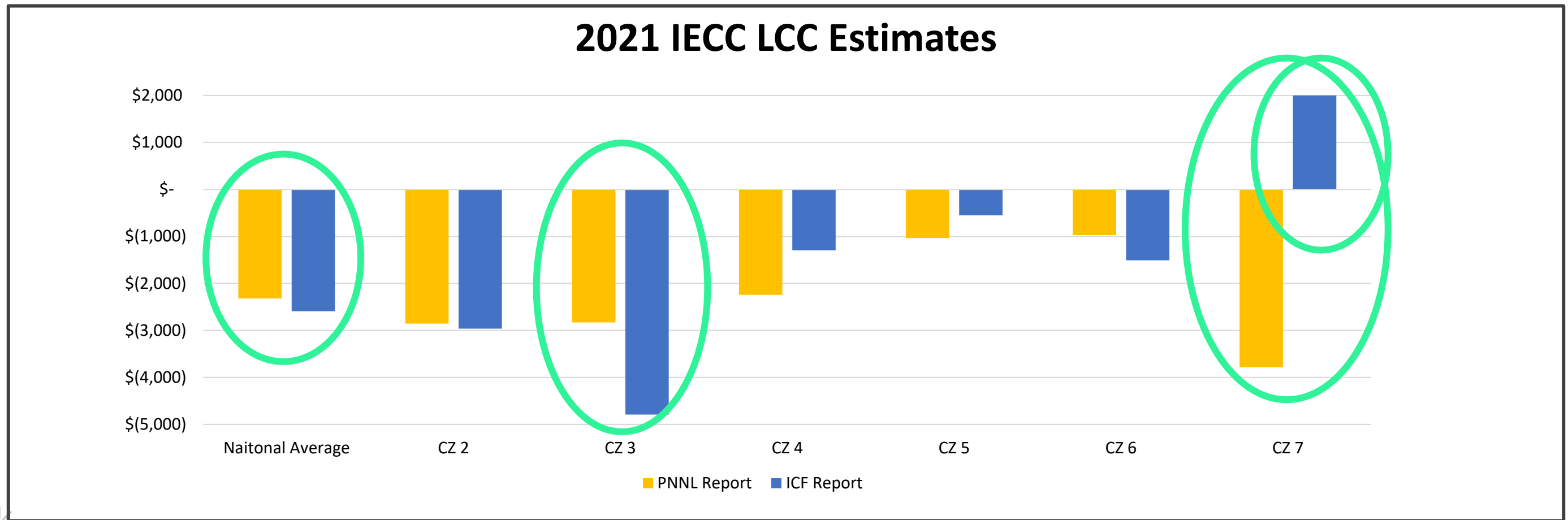
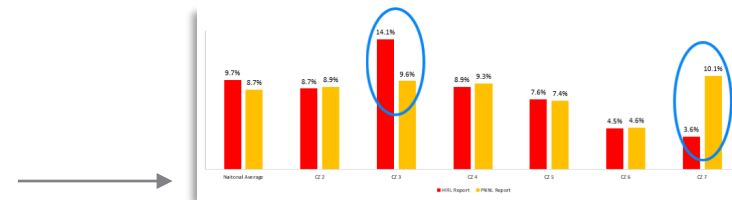
Cost Effectiveness Results: Simple Payback

- **HIRL** : average payback of 32 years,
 - ranging from 20-79 in each CZ
- **PNNL / ICF** : average payback of 10-12 years,
 - ranging from 2-28 in each CZ
- Incremental costs are the driver of this difference.



Cost Effectiveness Results: LCC

- **PNNL / ICF** estimated average net benefit (negative LCC) of ~\$2,300-\$2,600
 - Assuming the water heater option
 - ICF's estimate in CZ 7 was a net cost
 - Outliers in CZ 3 and 7 result in discrepancy in savings estimates



Cost Effectiveness Results

- ICF determined 2021 IECC is **cost effective** in all CZs,
 - multiple cost effective compliance options in each CZ
 - Negative LCC (blue) indicates net savings (i.e., cost effective)

Table 11b LCC* relative to 2018 Baseline Reference House (\$ / house)

	National Average	CZ 2 Phoenix	CZ 3 Memphis	CZ 4 Baltimore	CZ 5 Chicago	CZ 6 Helena	CZ 7 Duluth
2021 without additional efficiency package options	(1,625.67)	(1,350.06)	(2,783.91)	(1,318.71)	(690.87)	(1,757.92)	1,411.09
2021 with HVAC option	(1,932.88)	(180.50)	(1,710.75)	(2,728.63)	(3,300.21)	(4,796.20)	(2,947.04)
2021 with Water Heater option	(2,590.72)	(2,963.03)	(4,790.45)	(1,295.80)	(550.40)	(1,507.53)	2,131.96
2021 with Ventilation option	1,102.13	1,892.34	(49.29)	1,388.91	1,679.62	(9.37)	933.64
2021 with Duct option, slab house	(2,670.47)	(2,199.57)	(2,958.79)	(2,324.45)	(2,612.12)	(5,121.73)	(3,784.46)
2021 with Duct option, vented crawlspace house	n/a	n/a	(3,688.02)	(2,759.88)	n/a	n/a	n/a



Takeaways

Takeaways

Significant Savings

- The 2021 IECC saves ~9% nationally and ~4-10% savings in each CZ

Incremental Cost Increases

- ICF/PNNL estimates incremental costs of ~\$2,300-\$2,700 nationally and ~\$1,250-\$4,000 in each CZ
- HIRL cost estimates appear high

Cost Effective for Homeowners

- ICF/PNNL estimates net benefit to homeowners of ~\$2,300-\$2,600 nationally

Who to reference?

- PNNL's report has reasonable cost estimates and a robust methodology
- It should be referenced when evaluating adoption of the 2021 IECC



Q&A

Get in touch with us:

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Reports Referenced

- ICF Report
 - <https://energyefficientcodes.org/wp-content/uploads/ICF-2021-IECC-Cost-effectiveness-Analysis.pdf>
- ICF Comparison Report
 - <https://energyefficientcodes.org/wp-content/uploads/Comparison-of-2021-IECC-Residential-Cost-Effectiveness-Analyses.pdf>
- HIRL Report
 - <https://www.nahb.org/-/media/NAHB/advocacy/docs/top-priorities/codes/code-adoption/2021-iecc-cost-effectiveness-analysis-hirl.pdf>
- PNNL Cost Effectiveness Report
 - https://www.energycodes.gov/sites/default/files/2021-07/2021IECC_CostEffectiveness_Final_Residential.pdf
- PNNL Savings
 - https://www.energycodes.gov/sites/default/files/2021-07/2021_IECC_Final_Determination_AnalysisTSD.pdf
- DOE State Savings Analysis
 - <https://www.energycodes.gov/national-and-state-analysis>