CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

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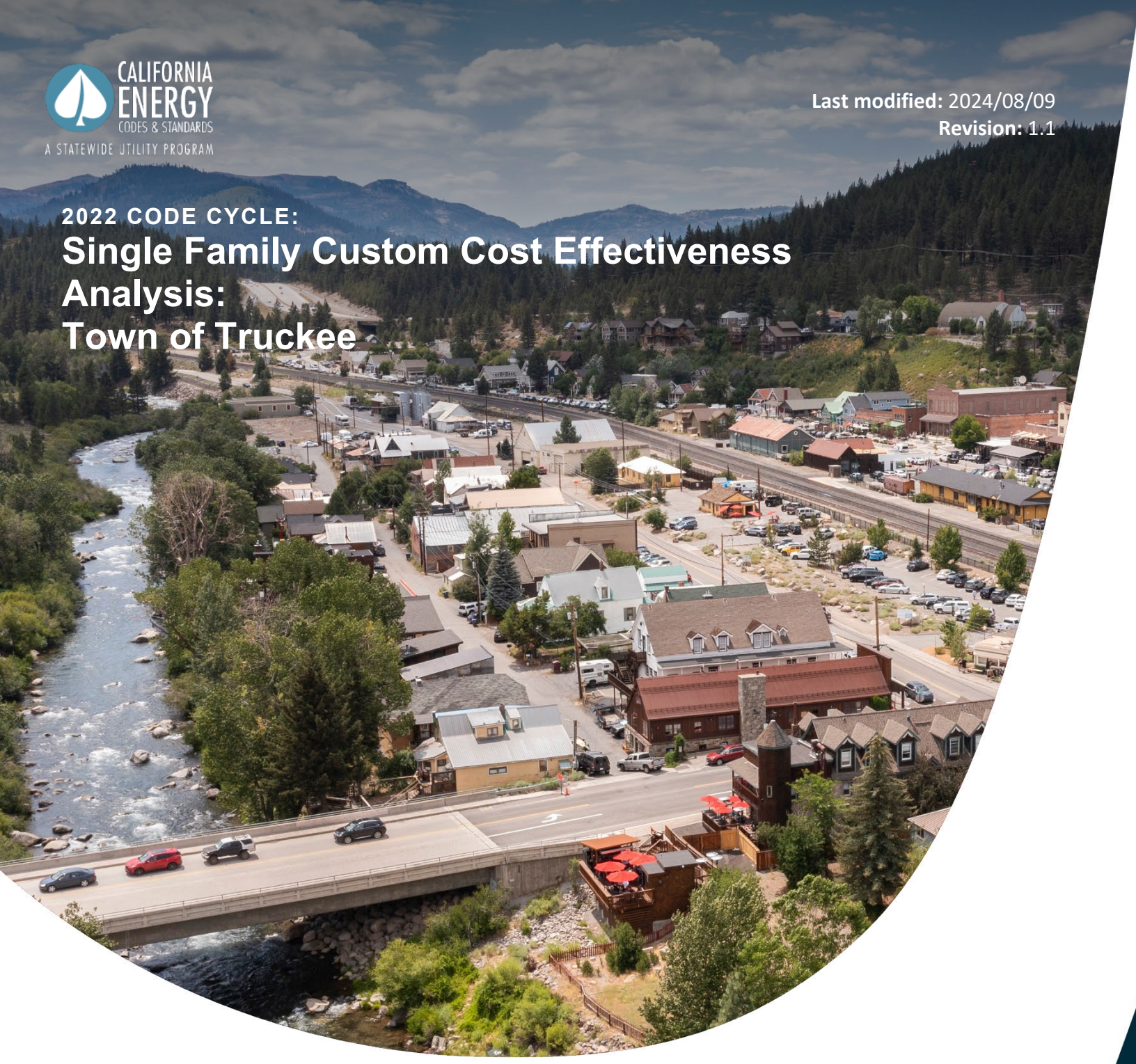

2022 CODE CYCLE:

Single Family Custom Cost Effectiveness Analysis: Town of Truckee

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Acronym List

AFUE – Annual Fuel Utilization Efficiency

B/C – Benefit-to-Cost Ratio

CBECC - California Building Energy Code Compliance

CBSC - California Building Standards Commission

CEC - California Energy Commission

CPAU – City of Palo Alto Utilities

CZ – Climate Zone

GHG - Greenhouse Gas

HSPF2 – Heating Seasonal Performance Factor 2

IOU – Investor-Owned Utility

kWh – Kilowatt Hour

LADWP – Los Angeles Department of Water and Power

Liberty – Liberty Utilities

NPV – Net Present Value

PG&E – Pacific Gas & Electric (utility)

POU – Publicly Owned Utility

PV - Solar Photovoltaic

SCE – Southern California Edison (utility)

SCG – Southern California Gas (utility)

SDG&E – San Diego Gas & Electric (utility)

SEER2 – Seasonal Energy Efficiency Ratio 2

TDV - Time Dependent Valuation

TDPUD – Truckee Donner Public Utility District

Title 24 – California Code of Regulations Title 24, Part 6

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1 Introduction

The California Codes and Standards (C&S) Reach Codes program provides technical support to local governments considering adopting a local ordinance (reach code) intended to support meeting local and/or statewide energy efficiency and greenhouse gas reduction goals. The program facilitates adoption and implementation of the code when requested by local jurisdictions by providing resources such as cost-effectiveness studies, model language, sample findings, and other supporting documentation.

The California Building Energy Efficiency Standards Title 24, Part 6 (Title 24) (CEC, 2019) is maintained and updated every three years by two state agencies: the California Energy Commission (the Energy Commission) and the Building Standards Commission (BSC). In addition to enforcing the code, local jurisdictions have the authority to adopt local energy efficiency ordinances—or reach codes—that exceed the minimum standards defined by Title 24 (as established by Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards). Local jurisdictions must demonstrate that the requirements of the proposed ordinance are cost-effective and do not result in buildings consuming more energy than is permitted by Title 24. In addition, the jurisdiction must obtain approval from the Energy Commission and file the ordinance with the BSC for the ordinance to be legally enforceable.

This report is an addendum to the *2022 Single Family Retrofit Cost-effectiveness Study* (Statewide Reach Codes Team, 2024) modified to accurately represent local conditions for the town of Truckee in California Climate Zone 16. The study analyzes cost-effective measure upgrades in existing single family buildings that exceed the minimum state requirements, the 2022 Building Energy Efficiency Standards, effective January 1, 2023. Local jurisdictions in California may consider adopting local energy ordinances to achieve energy savings beyond what will be accomplished by enforcing building efficiency requirements that apply statewide. This report was developed in coordination with the California Statewide Investor-Owned Utilities (IOUs) Codes and Standards Program, key consultants, and engaged cities—collectively known as the Statewide Reach Codes Team.

The methodology, prototype characteristics, and measure packages are retained from the main study referenced above except for the energy costs are calculated using local Truckee utility rates, the models are run with the Truckee weather file, and a subset of equipment costs gathered by TRC for Truckee have been incorporated. Measure packages include upgrades in existing single family buildings that exceed the minimum state requirements. It evaluates efficiency measures such as adding insulation, replacing windows, and duct upgrades, fuel substitution measures that upgrade space heating and water heating to heat pumps, and solar photovoltaics (PV). A 1,665 square foot single family home prototype with an attached garage was evaluated in this study.

Local jurisdictions may also adopt ordinances that amend different Parts of the California Building Standards Code or may elect to amend other state or municipal codes. The decision regarding which code to amend will determine the specific requirements that must be followed for an ordinance to be legally enforceable. Although a cost-effectiveness study is only required to amend Part 6 of the CA Building Code, it is important to understand the economic impacts of any policy decision. This study documents the estimated costs, benefits, energy impacts and greenhouse gas emission reductions that may result from implementing an ordinance based on the results to help residents, local leadership, and other stakeholders make informed policy decisions.

Model ordinance language and other resources are posted on the C&S Reach Codes Program website at LocalEnergyCodes.com. Local jurisdictions that are considering adopting an ordinance may contact the program for further technical support at info@localenergycodes.com.

2 Methodology and Assumptions

2.1 Reach Codes

This section describes the approach to calculating cost-effectiveness including benefits, costs, metrics, and utility rate selection.

2.1.1 Benefits

This analysis used two different metrics to assess the cost-effectiveness of the proposed upgrades. Both methodologies require estimating and quantifying the incremental costs and energy savings associated with each energy efficiency measure. The main difference between the methodologies is the way they value energy impacts:

- On-Bill: Customer-based lifecycle cost approach that values energy based upon estimated site energy usage and customer on-bill savings using electricity and natural gas utility rate schedules over a 30-year duration, accounting for a three percent discount rate and energy cost inflation per Appendix 7.2.3.
- Long-term Systemwide Cost (LSC): Formerly known as Time Dependent Valuation (TDV) energy cost savings, LSC reflects the Energy Commission's current LCC methodology, which is intended to capture the total value or cost of energy use over 30 years. This method accounts for the hourly cost of marginal generation, transmission and distribution, fuel, capacity, losses, and cap-and-trade-based CO2 emissions (California Energy Commission, 2023). This is the methodology used by the Energy Commission in evaluating cost-effectiveness for efficiency measures in the 2025 Energy Code.

The Reach Codes Team performed energy simulations using the 2025 research version of the Residential California Building Energy Code Compliance software (CBECC).

2.1.2 Costs

The Reach Codes Team assessed the incremental costs and savings of the energy packages over the lifecycle of 30 years. Incremental costs represent the equipment, installation, replacement, and maintenance costs of the proposed measure relative to the 2022 Title 24 Standards minimum requirements or standard industry practices. The Reach Codes Team obtained measure costs from a contractor survey conducted in the summer of 2023. Truckee specific costs were also incorporated into this analysis and reported in separate tables in the results section. Note that only the heat pump space heater Truckee costs were used because the Truckee cost analysis did not include a gas water heater cost, so an incremental cost for the heat pump water heater measures could not be obtained.

2.1.3 Metrics

Cost-effectiveness is presented using net present value (NPV) and benefit-to-cost (B/C) ratio metrics.

- NPV: The Reach Codes Team uses net savings (NPV benefits minus NPV costs) as the cost-effectiveness metric. If the net savings of a measure or package is positive, it is considered cost effective. Negative net savings represent net costs to the consumer. A measure that has negative energy cost benefits (energy cost increase) can still be cost effective if the costs to implement the measure are even more negative (i.e., construction and maintenance cost savings).
- B/C Ratio: Ratio of the present value of all benefits to the present value of all costs over 30 years (NPV benefits divided by NPV costs). The criteria for cost-effectiveness is a B/C greater than 1.0. A value of one indicates the savings over the life of the measure are equivalent to the incremental cost of that measure. A value greater than one represents a positive return on investment.

Improving the energy performance of a building often requires an initial investment. In most cases the benefit is represented by annual on-bill utility or LSC savings, and the cost by incremental first cost and replacement costs. However, some packages result in initial construction cost savings (negative incremental cost), and either energy cost

savings (positive benefits), or increased energy costs (negative benefits). In cases where both construction costs and energy-related savings are negative, the construction cost savings are treated as the benefit while the increased energy costs are the cost. In cases where a measure or package is cost-effective immediately (i.e., upfront construction cost savings and lifetime energy cost savings), B/C ratio cost-effectiveness is represented by ">1". Because of these situations, NPV savings are also reported, which, in these cases, are positive values.

2.1.4 Utility Rates

In coordination with the Town of Truckee, the Reach Codes Team determined appropriate tariffs for each package, summarized in Table 1, based on the annual load profile of the prototype and the corresponding package, and the most prevalent rate for each building type. Both Truckee Donner Public Utility District (TDPUD) and Liberty Utilities (Liberty) utility rates were evaluated in addition to the impacts for permanent versus nonpermanent residents. For a more detailed breakdown of the rates selected refer to Appendix 7.2 Utility Rate Schedules.

Table 1. Utility Tariffs in Town of Truckee

Residential (Single Family and Detached ADU)

Electric / Gas Utility		Electricity	Natural Gas
TDPUD / Southwest Gas	Permanent Resident	P10	GN 10
	Nonpermanent Resident	S10	GN 15
Liberty / Southwest Gas	Permanent Resident	D-1	GN 10
	Nonpermanent Resident	D-1 (without baseline quantities	GN 15

Utility rates are assumed to escalate over time according to the assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. A second set of escalation rates were also evaluated to demonstrate the impact that utility cost changes have on cost-effectiveness over time. This utility rate escalation sensitivity analysis, presented in Section 4.4 Sensitivities, was based on those used within the 2025 LSC factors (LSC replaces TDV in the 2025 code cycle) which assumed steep increases in gas rates in the latter half of the analysis period. Appendix 7.2.3 and the main 2022 Single Family Retrofit Cost-effectiveness Study (Statewide Reach Codes Team, 2024) for details.

2.2 Greenhouse Gas Emissions

The analysis uses the greenhouse gas (GHG) emissions estimates built-in to CBECC-Res. There are 8760 hourly multipliers accounting for time dependent energy use and carbon emissions based on source emissions, including renewable portfolio standard projections. Natural gas fugitive emissions, which are shown to be substantial, are not included. There are two strings of multipliers—one for Northern California climate zones, and another for Southern California climate zones.[1]

[1] CBECC-Res multipliers are the same for CZs 1-5 and 11-13 (presumed to be Northern California), while there is another set of multipliers for CZs 6-10 and 14-16 (assumed to be Southern California).

3 Prototype Designs and Measure Packages

3.1 Prototype Characteristics

The Energy Commission defines building prototypes which it uses to evaluate the cost-effectiveness of proposed changes to Title 24 requirements. Average home size has steadily increased over time, and the Energy Commission single family new construction prototypes are larger than many existing single family homes across California. For this analysis, a 1,665 square foot prototype was evaluated. Table 2 describes the basic characteristics of the single family prototype. Additions are not evaluated in this analysis as they are already addressed in Section 150.2 of Title 24, Part 6. The CEC has proposed significant changes to the 2025 Energy Code that would remove the allowance of gas space heating and water heating equipment for additions and instead require additions to follow the same space heating and water heating equipment requirements as new construction (California Energy Commission, 2023).

Table 2: Residential Prototype Characteristics

	Specification
Existing Conditioned Floor Area	1,665 ft^2
Num. of Stories	1
Num. of Bedrooms	3
Window-to-Floor Area Ratio	13%
Attached Garage	2-car garage

Three building vintages were evaluated to determine sensitivity of existing building performance on cost-effectiveness of upgrades. For example, it is widely recognized that adding attic insulation in an older home with no insulation is cost-effective, however, newer homes will likely have existing attic insulation reducing the cost-effectiveness of an incremental addition of insulation. The building characteristics for each vintage were determined based on either prescriptive requirements from Title 24 that were in effect or standard construction practice during that time period. Homes built under 2001 Title 24 are subject to prescriptive envelope code requirements very similar to homes built under the 2005 code cycle, which was in effect until January 1, 2010.

Table 3 summarizes the assumptions for each of the three vintages. Additionally, the analysis assumed the following features when modeling the prototype buildings. Efficiencies were defined by year of the most recent equipment replacement based on standard equipment lifetimes.

- Individual space conditioning and water heating systems, one per single family building.
- Split-system air conditioner with natural gas furnace.
    - Scenarios with an existing natural gas wall furnace without AC were also evaluated.
- Small storage natural gas water heater.
    - Scenarios with an existing electric resistance storage water heater were also evaluated.
- Gas cooktop, oven, and clothes dryer.

The methodology applied in the analyses begins with a design that matches the specifications as described in Table 3 for each of the three vintages. Prospective energy efficiency measures were modeled to determine the projected energy performance and utility cost impacts relative to the baseline vintage. In some cases, where logical, measures were packaged together.

Table 3. Efficiency Characteristics for Three Vintage Cases

Building Component Efficiency Feature	Vintage Case		
	Pre-1978	1978-1991	1992-2010
Envelope			
Exterior Walls	2x4, 16-inch on center wood frame, R-0[a]	2x4 16 inch on center wood frame, R-11	2x4 16 inch on center wood frame, R-13
Foundation Type & Insulation	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-0 (CZ 1 & 16)	Uninsulated slab (CZ 2-15) Raised floor, R-19 (CZ 1 & 16)
Ceiling Insulation & Attic Type	Vented attic, R-5 @ ceiling level for CZ 6 & 7, Vented attic, R-11 @ ceiling level (all other CZs)	Vented attic, R-19 @ ceiling level	Vented attic, R-30 @ ceiling level
Roofing Material & Color	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)	Asphalt shingles, dark (0.10 reflectance, 0.85 emittance)
Radiant Barrier	No	No	No
Window Type: U-factor/SHGC[b]	Metal, single pane: 1.16/0.76	Metal, dual pane: 0.79/0.70	Vinyl, dual pane Low-E: 0.55/0.40
House Infiltration at 50 Pascals	15 ACH50	10 ACH50	7 ACH50
HVAC Equipment			
Heating Efficiency	78 AFUE (assumes 2 replacements)	78 AFUE (assumes 1 replacement)	78 AFUE
Cooling Efficiency	10 SEER (assumes 2 replacements)	10 SEER (assumes 1 replacement)	13 SEER, 11 EER
Duct Location & Details	Attic, R-2.1, 30% leakage at 25 Pa	Attic, R-2.1, 25% leakage at 25 Pa	Attic, R-4.2, 15% leakage at 25 Pa
Whole Building Mechanical Ventilation	None	None	None
Water Heating Equipment			
Water Heater Efficiency	0.575 Energy Factor (assumes 2 replacements)	0.575 Energy Factor (assumes 1 replacement)	0.575 Energy Factor
Water Heater Type	40-gallon gas storage	40-gallon gas storage	40-gallon gas storage
Pipe Insulation	None	None	None
Hot Water Fixtures	Standard, non-low flow	Standard, non-low flow	Standard, non-low flow

[a] Pre-1978 wall modeled with R-5 cavity insulation to better align wall system performance with monitored field data and not overestimate energy use.

[b] Window type selections were made based on conversations with window industry expert, Ken Nittler. If a technology was entering the market during the time period (e.g., Low-E during 1992-2010 or dual-pane during 1978-1991) that technology was included in the analysis. This provides a conservative assumption for overall building performance and additional measures may be cost-effective for buildings with lower performing windows, for example buildings with metal single pane windows in the 1978-1991 vintage.

4 Results

The primary objective of the evaluation is to identify cost-effective energy upgrade measures and packages for existing single family buildings, to support the design of local ordinances requiring upgrades, which may be triggered by different events, such as at the time of a significant remodel or at burnout of mechanical equipment.

The following describes which results are presented in the tables in this section. See the main 2022 Single Family Retrofit Cost-Effectiveness Study (Statewide Reach Codes Team, 2024) for details of the measures.

- Table 4 through Table 7 show the cost-effective results for pre-1978, 1978-1991 and 1992-2010 vintages for the standard heat pump space heaters (HPSH) and high efficiency HPSH measures that utilize Truckee measure costs. The results account for permanent and nonpermanent residents using Liberty D-1 and TDPUD rates.
- Table 8 through Table 23 show the cost-effective results for pre-1978, 1978-1991 and 1992-2010 vintage for heat HPSHs including dual fuel heat pumps (DFHPs), heat pump water heaters (HPWHs) and envelope and duct measures that utilize statewide measure costs. The results account for permanent residents using Liberty D-1 and TDPUD rates.
- Table 24 through Table 39 show the cost-effective results for pre-1978, 1978-1991 and 1992-2010 vintage for heat HPSHs including dual fuel heat pumps (DFHPs), heat pump water heaters (HPWHs) and envelope and duct measures that utilize statewide measure costs. The results account for nonpermanent residents using Liberty D-1 and TDPUD rates.

4.1 Truckee Costs (Permanent and Nonpermanent Residents)

Table 4: Liberty Permanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	HPSH (Std Efficiency)	(14,709)	1,252	5.24	74,976	44.05	($2,897)	($51,339)	($530)	$496	0.00	($51,834)	85.58	$41,928
	HPSH (High Efficiency)	(11,629)	1,252	5.70	85,485	49.20	($1,843)	($27,321)	$4,654	$9,007	0.00	($36,328)	7.35	$57,177
1978-1991	HPSH (Std Efficiency)	(11,882)	1,013	4.24	60,707	35.60	($2,315)	($40,981)	($530)	$496	0.00	($41,476)	69.29	$33,853
	HPSH (High Efficiency)	(9,427)	1,013	4.60	69,085	39.72	($1,476)	($21,842)	$4,654	$9,007	0.00	($30,849)	5.92	$44,306
1992-2010	HPSH (Std Efficiency)	(7,727)	661	2.75	39,721	23.09	($1,459)	($25,680)	($530)	$496	0.00	($26,175)	45.64	$22,132
	HPSH (High Efficiency)	(6,046)	661	3.00	45,455	25.95	($884)	($12,589)	$4,654	$9,007	0.00	($21,596)	3.96	$26,624

Table 5: Liberty Nonpermanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	HPSH (Std Efficiency)	(14,709)	1,252	5.24	74,976	44.05	($2,593)	($42,932)	($530)	$496	0.00	($43,428)	85.58	$41,928
	HPSH (High Efficiency)	(11,629)	1,252	5.70	85,485	49.20	($1,588)	($20,025)	$4,654	$9,007	0.00	($29,032)	7.35	$57,177
1978-1991	HPSH (Std Efficiency)	(11,882)	1,013	4.24	60,707	35.60	($2,092)	($34,618)	($530)	$496	0.00	($35,114)	69.29	$33,853
	HPSH (High Efficiency)	(9,427)	1,013	4.60	69,085	39.72	($1,291)	($16,357)	$4,654	$9,007	0.00	($25,364)	5.92	$44,306
1992-2010	HPSH (Std Efficiency)	(7,727)	661	2.75	39,721	23.09	($1,354)	($22,326)	($530)	$496	0.00	($22,821)	45.64	$22,132
	HPSH (High Efficiency)	(6,046)	661	3.00	45,455	25.95	($806)	($9,828)	$4,654	$9,007	0.00	($18,835)	3.96	$26,624

Table 6: TDPUD Permanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	HPSH (Std Efficiency)	(14,709)	1,252	5.24	74,976	44.05	($444)	$4,594	($530)	$496	9.27	$4,098	85.58	$41,928
	HPSH (High Efficiency)	(11,629)	1,252	5.70	85,485	49.20	$69	$16,282	$4,654	$9,007	1.81	$7,275	7.35	$57,177
1978-1991	HPSH (Std Efficiency)	(11,882)	1,013	4.24	60,707	35.60	($368)	$3,403	($530)	$496	6.87	$2,908	69.29	$33,853
	HPSH (High Efficiency)	(9,427)	1,013	4.60	69,085	39.72	$40	$12,721	$4,654	$9,007	1.41	$3,714	5.92	$44,306
1992-2010	HPSH (Std Efficiency)	(7,727)	661	2.75	39,721	23.09	($253)	$1,803	($530)	$496	3.64	$1,307	45.64	$22,132
	HPSH (High Efficiency)	(6,046)	661	3.00	45,455	25.95	$26	$8,179	$4,654	$9,007	0.91	($828)	3.96	$26,624

Table 7: TDPUD Nonpermanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	HPSH (Std Efficiency)	(14,709)	1,252	5.24	74,976	44.05	($580)	$2,966	($530)	$496	5.98	$2,470	85.58	$41,928
	HPSH (High Efficiency)	(11,629)	1,252	5.70	85,485	49.20	$4	$16,263	$4,654	$9,007	1.81	$7,255	7.35	$57,177
1978-1991	HPSH (Std Efficiency)	(11,882)	1,013	4.24	60,707	35.60	($466)	$2,460	($530)	$496	4.96	$1,964	69.29	$33,853
	HPSH (High Efficiency)	(9,427)	1,013	4.60	69,085	39.72	($1)	$13,060	$4,654	$9,007	1.45	$4,053	5.92	$44,306
1992-2010	HPSH (Std Efficiency)	(7,727)	661	2.75	39,721	23.09	($297)	$1,785	($530)	$496	3.60	$1,289	45.64	$22,132
	HPSH (High Efficiency)	(6,046)	661	3.00	45,455	25.95	$21	$9,039	$4,654	$9,007	1.00	$32	3.96	$26,624

4.2 Statewide Costs (Permanent Residents)

Table 8: Liberty Permanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	DFHP Existing Furnace	(3,482)	141	0.39	2,217	2.73	($837)	($17,402)	$2,397	$2,341	0.00	($19,742)	0.00	($10,982)
	DFHP New Furnace	(3,482)	137	0.37	1,865	2.53	($843)	($17,575)	$4,757	$6,295	0.00	($23,870)	0.00	($15,370)
	Ducted MSHP	(11,639)	1,252	5.69	85,452	49.20	($1,846)	($27,388)	$2,155	$4,314	0.00	($31,702)	15.33	$61,803
	Ductless MSHP (Std Efficiency)	(10,914)	1,158	5.27	78,572	45.48	($1,705)	($25,293)	$13,336	$21,679	0.00	($46,973)	2.79	$38,843
	Ductless MSHP (High Efficiency)	(6,970)	1,158	5.73	92,028	50.70	($362)	$5,317	$17,266	$28,132	0.19	($22,815)	3.17	$60,912
	HPSH + 3kW PV	(9,536)	1,252	5.38	92,627	45.64	($1,209)	($12,851)	$12,333	$15,656	0.00	($28,507)	3.62	$40,971
1978-1991	DFHP Existing Furnace	(2,813)	121	0.36	2,528	2.58	($655)	($13,491)	$2,397	$2,341	0.00	($15,831)	0.00	($8,468)
	DFHP New Furnace	(2,813)	118	0.34	2,225	2.42	($660)	($13,643)	$4,757	$6,295	0.00	($19,939)	0.00	($12,789)
	Ducted MSHP	(9,430)	1,013	4.60	69,073	39.72	($1,477)	($21,865)	$2,155	$4,314	0.00	($26,178)	12.36	$48,983
	Ductless MSHP (Std Efficiency)	(8,473)	911	4.16	62,134	35.94	($1,280)	($18,612)	$13,336	$21,679	0.00	($40,291)	2.23	$26,722
	Ductless MSHP (High Efficiency)	(4,448)	911	4.66	75,866	41.61	$67	$12,094	$17,266	$28,132	0.43	($16,038)	2.78	$49,940
	HPSH + 3kW PV	(6,710)	1,013	4.38	78,357	37.19	($636)	($2,693)	$12,333	$15,656	0.00	($18,349)	3.07	$32,363
1992-2010	DFHP Existing Furnace	(1,671)	67	0.18	965	1.17	($398)	($8,290)	$2,397	$2,341	0.00	($10,631)	0.00	($6,703)
	DFHP New Furnace	(1,671)	65	0.17	799	1.09	($401)	($8,370)	$4,757	$6,295	0.00	($14,666)	0.00	($10,857)
	Ducted MSHP	(6,049)	661	3.00	45,444	25.94	($885)	($12,609)	$2,155	$4,314	0.00	($16,923)	8.26	$31,301
	Ductless MSHP (Std Efficiency)	(5,357)	588	2.69	40,531	23.26	($749)	($10,384)	$13,336	$21,679	0.00	($32,063)	1.49	$10,522
	Ductless MSHP (High Efficiency)	(2,106)	588	3.13	51,625	28.22	$278	$13,043	$17,266	$28,132	0.46	($15,089)	2.02	$28,595
	HPSH + 3kW PV	(2,554)	661	2.89	57,371	24.68	$183	$11,743	$12,333	$15,656	0.75	($3,913)	2.26	$19,709

Table 9: Liberty Permanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	240V Fed. Min. HPWH	(2,208)	200	0.95	12,427	8.34	($402)	($6,807)	$4,332	$6,554	0.00	($13,361)	1.33	$2,188
	240V Market Std. NEEA HPWH	(2,041)	200	0.97	13,047	8.50	($346)	($5,519)	$5,193	$7,967	0.00	($13,486)	1.24	$1,906
	240V Market Std. NEEA HPWH + DR	(1,846)	200	0.99	13,735	8.76	($280)	($4,021)	$5,193	$7,967	0.00	($11,988)	1.42	$3,372
	120V Market Std. NEEA HPWH	(1,206)	200	1.07	15,865	9.65	($63)	$919	$2,893	$4,273	0.22	($3,354)	3.78	$11,878
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,813	8.05	($434)	($7,578)	$4,751	$6,973	0.00	($14,551)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,067)	139	0.72	10,215	6.46	($115)	($999)	$4,413	$6,634	0.00	($7,633)	1.42	$2,806
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,072)	214	1.05	14,306	9.29	($332)	($5,053)	$5,492	$7,714	0.00	($12,767)	1.49	$3,742
	240V Fed. Min. HPWH + 3kW PV	2,964	200	1.09	30,077	9.93	$1,214	$30,039	$13,940	$18,128	1.66	$11,911	1.24	$4,300

Table 10: Liberty Permanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	240V Fed. Min. HPWH	(2,212)	199	0.95	12,328	8.30	($392)	($6,616)	$4,332	$6,554	0.00	($13,170)	1.31	$2,021
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,936	8.45	($338)	($5,363)	$5,193	$7,967	0.00	($13,330)	1.21	$1,690
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,620	8.70	($272)	($3,863)	$5,193	$7,967	0.00	($11,830)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,769	9.61	($59)	$995	$2,893	$4,273	0.23	($3,278)	3.74	$11,728
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($421)	($7,309)	$4,751	$6,973	0.00	($14,282)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,090)	143	0.74	10,563	6.68	($107)	($772)	$4,413	$6,634	0.00	($7,407)	1.48	$3,156
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,063)	214	1.05	14,327	9.30	($318)	($4,737)	$5,492	$7,714	0.00	($12,451)	1.48	$3,725
	240V Fed. Min. HPWH + 3kW PV	2,961	199	1.09	29,978	9.89	$1,211	$29,942	$13,940	$18,128	1.65	$11,814	1.22	$3,917

Table 11: Liberty Permanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	240V Fed. Min. HPWH	(2,213)	199	0.95	12,314	8.30	($380)	($6,377)	$4,332	$6,554	0.00	($12,931)	1.31	$2,004
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,919	8.44	($325)	($5,123)	$5,193	$7,967	0.00	($13,090)	1.21	$1,673
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,599	8.70	($262)	($3,677)	$5,193	$7,967	0.00	($11,644)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,742	9.60	($55)	$1,038	$2,893	$4,273	0.24	($3,235)	3.74	$11,711
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($409)	($7,057)	$4,751	$6,973	0.00	($14,029)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,087)	151	0.79	11,342	7.10	($93)	($385)	$4,413	$6,634	0.00	($7,020)	1.62	$4,122
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,056)	213	1.04	14,230	9.25	($305)	($4,502)	$5,492	$7,714	0.00	($12,215)	1.47	$3,658
	240V Fed. Min. HPWH + 3kW PV	2,960	199	1.09	29,965	9.89	$1,205	$29,763	$13,940	$18,128	1.64	$11,635	1.20	$3,634

Table 12: Liberty Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary Pre1978

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	30% Air Sealing	62	66	0.39	6,790	3.63	$127	$3,698	$4,684	$4,684	0.79	($986)	1.83	$3,891
	New Ducts: R-6	635	260	1.60	28,202	14.95	$622	$17,343	$4,808	$4,808	3.61	$12,534	7.67	$32,071
	New Ducts: R-8	653	270	1.66	29,236	15.49	$644	$17,949	$6,311	$6,311	2.84	$11,638	6.05	$31,901
	Duct Sealing: 10%	246	186	1.12	19,478	10.41	$382	$10,977	$2,590	$2,590	4.24	$8,388	9.61	$22,302
	Wall Insulation: R-13	162	159	0.95	16,413	8.79	$310	$8,988	$2,950	$2,950	3.05	$6,037	7.02	$17,762
	Attic Insulation: R-38	267	116	0.70	12,481	6.56	$273	$7,632	$6,762	$6,762	1.13	$870	2.40	$9,438
	Attic Insulation: R-49	295	127	0.78	13,741	7.22	$301	$8,409	$7,446	$7,446	1.13	$963	2.40	$10,419
	R-19 Raised Floor Insulation	(19)	257	1.51	25,579	13.97	$414	$12,511	$3,633	$3,633	3.44	$8,879	8.71	$28,002
	R-30 Raised Floor Insulation	(35)	295	1.74	29,364	16.07	$471	$14,284	$4,113	$4,113	3.47	$10,171	8.83	$32,184
	Cool Roof (0.20 Ref) (at roof replacement)	66	(32)	(0.18)	(2,999)	(1.70)	($32)	($1,123)	$893	$1,203	0.00	($2,326)	0.00	($4,683)
	Cool Roof (0.25 Ref) (at roof replacement)	92	(49)	(0.28)	(4,576)	(2.58)	($52)	($1,759)	$1,786	$2,407	0.00	($4,166)	0.00	($7,735)
	Window Upgrade: 0.28 vs 0.35 U-factor	318	183	1.11	19,370	10.30	$399	$11,319	$11,871	$11,871	0.95	($552)	2.11	$13,120

Table 13: Liberty Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	30% Air Sealing	39	40	0.24	4,154	2.23	$78	$2,267	$4,684	$4,684	0.48	($2,417)	1.11	$527
	New Ducts: R-6	467	187	1.15	20,328	10.79	$451	$12,547	$4,808	$4,808	2.61	$7,739	5.54	$21,815
	New Ducts: R-8	480	197	1.21	21,333	11.33	$471	$13,118	$6,311	$6,311	2.08	$6,807	4.42	$21,578
	Duct Sealing: 10%	368	109	0.68	12,119	6.39	$291	$7,943	$2,590	$2,590	3.07	$5,354	6.24	$13,561
	Wall Insulation: R-13	88	41	0.25	4,389	2.33	$95	$2,655	$2,555	$2,555	1.04	$100	2.23	$3,139
	Attic Insulation: R-38	107	51	0.31	5,493	2.91	$118	$3,311	$3,612	$3,612	0.92	($301)	1.97	$3,515
	Attic Insulation: R-49	19	249	1.47	24,932	13.58	$412	$12,360	$3,633	$3,633	3.40	$8,727	8.48	$27,186
	R-19 Raised Floor Insulation	5	289	1.70	28,891	15.76	$473	$14,236	$4,113	$4,113	3.46	$10,124	8.68	$31,602
	R-30 Raised Floor Insulation	24	(24)	(0.14)	(2,292)	(1.26)	($31)	($995)	$893	$1,203	0.00	($2,198)	0.00	($3,917)
	Cool Roof (0.20 Ref) (at roof replacement)	45	(36)	(0.21)	(3,453)	(1.89)	($45)	($1,457)	$1,786	$2,407	0.00	($3,864)	0.00	($6,469)
	Cool Roof (0.25 Ref) (at roof replacement)	208	153	0.92	15,975	8.56	$315	$9,043	$11,871	$11,871	0.76	($2,828)	1.72	$8,592
	Window Upgrade: 0.28 vs 0.35 U-factor	39	40	0.24	4,154	2.23	$78	$2,267	$4,684	$4,684	0.48	($2,417)	1.11	$527

Table 14: Liberty Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	30% Air Sealing	25	25	0.15	2,603	1.40	$49	$1,411	$4,684	$4,684	0.30	($3,273)	0.70	($1,404)
	New Ducts: R-6	218	51	0.32	5,839	3.06	$149	$4,016	$4,808	$4,808	0.84	($792)	1.64	$3,100
	New Ducts: R-8	235	61	0.38	6,850	3.60	$170	$4,600	$6,311	$6,311	0.73	($1,711)	1.46	$2,896
	Duct Sealing: 10%	35	26	0.15	2,674	1.44	$52	$1,501	$1,400	$1,400	1.07	$101	2.44	$2,013
	Attic Insulation: R-38	24	12	0.07	1,255	0.67	$27	$751	$1,781	$1,781	0.42	($1,031)	0.91	($166)
	Attic Insulation: R-49	46	21	0.13	2,295	1.21	$49	$1,380	$1,827	$1,827	0.75	($448)	1.62	$1,136
	Cool Roof (0.20 Ref) (at roof replacement)	20	(17)	(0.10)	(1,605)	(0.89)	($21)	($675)	$893	$1,203	0.00	($1,879)	0.00	($3,102)
	Cool Roof (0.25 Ref) (at roof replacement)	25	(25)	(0.15)	(2,458)	(1.35)	($33)	($1,063)	$1,786	$2,407	0.00	($3,470)	0.00	($5,321)
	Window Upgrade: 0.28 vs 0.35 U-factor	87	122	0.72	12,453	6.72	$224	$6,544	$11,871	$11,871	0.55	($5,327)	1.31	$3,713

Table 15: Liberty Permanent Rate Solar PV Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	3kW PV	5,173	0	0.14	17,651	1.59	$1,561	$35,593	$9,608	$11,574	3.08	$24,019	0.92	($868)
1978-1991	3kW PV	4,766	0	0.13	16,264	1.47	$1,439	$32,796	$9,608	$11,574	2.83	$21,222	0.87	($1,484)
1992-2010	3kW PV	4,266	0	0.12	14,555	1.31	$1,287	$29,352	$9,608	$11,574	2.54	$17,777	0.81	($2,200)

Table 16: TDPUD Permanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	DFHP Existing Furnace	(3,482)	141	0.39	2,217	2.73	($350)	($6,294)	$2,397	$2,341	0.00	($8,634)	0.00	($10,982)
	DFHP New Furnace	(3,482)	137	0.37	1,865	2.53	($356)	($6,467)	$4,757	$6,295	0.00	($12,763)	0.00	($15,370)
	Ducted MSHP	(11,639)	1,252	5.69	85,452	49.20	$68	$16,245	$2,155	$4,314	3.77	$11,931	15.33	$61,803
	Ductless MSHP (Std Efficiency)	(10,914)	1,158	5.27	78,572	45.48	$33	$14,329	$13,336	$21,679	0.66	($7,351)	2.79	$38,843
	Ductless MSHP (High Efficiency)	(6,970)	1,158	5.73	92,028	50.70	$690	$29,294	$17,266	$28,132	1.04	$1,162	3.17	$60,912
	HPSH + 3kW PV	(9,536)	1,252	5.38	92,627	45.64	$418	$24,223	$12,333	$15,656	1.55	$8,567	3.62	$40,971
1978-1991	DFHP Existing Furnace	(2,813)	121	0.36	2,528	2.58	($272)	($4,752)	$2,397	$2,341	0.00	($7,092)	0.00	($8,468)
	DFHP New Furnace	(2,813)	118	0.34	2,225	2.42	($277)	($4,904)	$4,757	$6,295	0.00	($11,199)	0.00	($12,789)
	Ducted MSHP	(9,430)	1,013	4.60	69,073	39.72	$40	$12,709	$2,155	$4,314	2.95	$8,395	12.36	$48,983
	Ductless MSHP (Std Efficiency)	(8,473)	911	4.16	62,134	35.94	$30	$11,256	$13,336	$21,679	0.52	($10,424)	2.23	$26,722
	Ductless MSHP (High Efficiency)	(4,448)	911	4.66	75,866	41.61	$700	$26,529	$17,266	$28,132	0.94	($1,603)	2.78	$49,940
	HPSH + 3kW PV	(6,710)	1,013	4.38	78,357	37.19	$493	$23,033	$12,333	$15,656	1.47	$7,377	3.07	$32,363
1992-2010	DFHP Existing Furnace	(1,671)	67	0.18	965	1.17	($172)	($3,135)	$2,397	$2,341	0.00	($5,475)	0.00	($6,703)
	DFHP New Furnace	(1,671)	65	0.17	799	1.09	($174)	($3,215)	$4,757	$6,295	0.00	($9,510)	0.00	($10,857)
	Ducted MSHP	(6,049)	661	3.00	45,444	25.94	$26	$8,168	$2,155	$4,314	1.89	$3,854	8.26	$31,301
	Ductless MSHP (Std Efficiency)	(5,357)	588	2.69	40,531	23.26	$22	$7,204	$13,336	$21,679	0.33	($14,476)	1.49	$10,522
	Ductless MSHP (High Efficiency)	(2,106)	588	3.13	51,625	28.22	$563	$19,541	$17,266	$28,132	0.69	($8,591)	2.02	$28,595
	HPSH + 3kW PV	(2,554)	661	2.89	57,371	24.68	$608	$21,432	$12,333	$15,656	1.37	$5,776	2.26	$19,709

Table 17: TDPUD Permanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	240V Fed. Min. HPWH	(2,208)	200	0.95	12,427	8.34	($47)	$1,285	$4,332	$6,554	0.20	($5,268)	1.33	$2,188
	240V Market Std. NEEA HPWH	(2,041)	200	0.97	13,047	8.50	($18)	$1,945	$5,193	$7,967	0.24	($6,023)	1.24	$1,906
	240V Market Std. NEEA HPWH + DR	(1,846)	200	0.99	13,735	8.76	$15	$2,697	$5,193	$7,967	0.34	($5,270)	1.42	$3,372
	120V Market Std. NEEA HPWH	(1,206)	200	1.07	15,865	9.65	$120	$5,096	$2,893	$4,273	1.19	$824	3.78	$11,878
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,813	8.05	($65)	$819	$4,751	$6,973	0.12	($6,153)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,067)	139	0.72	10,215	6.46	$44	$2,625	$4,413	$6,634	0.40	($4,009)	1.42	$2,806
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,072)	214	1.05	14,306	9.29	($1)	$2,497	$5,492	$7,714	0.32	($5,217)	1.49	$3,742
	240V Fed. Min. HPWH + 3kW PV	2,964	200	1.09	30,077	9.93	$814	$20,915	$13,940	$18,128	1.15	$2,787	1.24	$4,300

Table 18: TDPUD Permanent Rate HPWH Single Family Cost-Effectiveness 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	240V Fed. Min. HPWH	(2,212)	199	0.95	12,328	8.30	($51)	$1,174	$4,332	$6,554	0.18	($5,380)	1.31	$2,021
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,936	8.45	($22)	$1,825	$5,193	$7,967	0.23	($6,142)	1.21	$1,690
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,620	8.70	$11	$2,577	$5,193	$7,967	0.32	($5,390)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,769	9.61	$117	$4,989	$2,893	$4,273	1.17	$716	3.74	$11,728
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($67)	$765	$4,751	$6,973	0.11	($6,208)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,090)	143	0.74	10,563	6.68	$46	$2,718	$4,413	$6,634	0.41	($3,916)	1.48	$3,156
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,063)	214	1.05	14,327	9.30	($2)	$2,462	$5,492	$7,714	0.32	($5,251)	1.48	$3,725
	240V Fed. Min. HPWH + 3kW PV	2,961	199	1.09	29,978	9.89	$810	$20,804	$13,940	$18,128	1.15	$2,676	1.22	$3,917

Table 19: TDPUD Permanent Rate HPWH Single Family Cost-Effectiveness 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	240V Fed. Min. HPWH	(2,213)	199	0.95	12,314	8.30	($57)	$998	$4,332	$6,554	0.15	($5,556)	1.31	$2,004
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,919	8.44	($28)	$1,650	$5,193	$7,967	0.21	($6,317)	1.21	$1,673
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,599	8.70	$5	$2,398	$5,193	$7,967	0.30	($5,569)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,742	9.60	$111	$4,808	$2,893	$4,273	1.13	$535	3.74	$11,711
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($73)	$598	$4,751	$6,973	0.09	($6,375)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,087)	151	0.79	11,342	7.10	$54	$2,969	$4,413	$6,634	0.45	($3,666)	1.62	$4,122
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,056)	213	1.04	14,230	9.25	($8)	$2,257	$5,492	$7,714	0.29	($5,457)	1.47	$3,658
	240V Fed. Min. HPWH + 3kW PV	2,960	199	1.09	29,965	9.89	$804	$20,628	$13,940	$18,128	1.14	$2,500	1.20	$3,634

Table 20: TDPUD Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary Pre1978

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	30% Air Sealing	62	66	0.39	6,790	3.63	$568	$13,741	$4,684	$4,684	2.93	$9,057	1.83	$3,891
	New Ducts: R-6	635	260	1.60	28,202	14.95	$985	$25,617	$4,808	$4,808	5.33	$20,809	7.67	$32,071
	New Ducts: R-8	653	270	1.66	29,236	15.49	$1,004	$26,170	$6,311	$6,311	4.15	$19,859	6.05	$31,901
	Duct Sealing: 10%	246	186	1.12	19,478	10.41	$798	$20,454	$2,590	$2,590	7.90	$17,864	9.61	$22,302
	Wall Insulation: R-13	162	159	0.95	16,413	8.79	$737	$18,722	$2,950	$2,950	6.35	$15,771	7.02	$17,762
	Attic Insulation: R-38	267	116	0.70	12,481	6.56	$686	$17,042	$6,762	$6,762	2.52	$10,280	2.40	$9,438
	Attic Insulation: R-49	295	127	0.78	13,741	7.22	$710	$17,732	$7,446	$7,446	2.38	$10,286	2.40	$10,419
	R-19 Raised Floor Insulation	(19)	257	1.51	25,579	13.97	$866	$22,820	$3,633	$3,633	6.28	$19,187	8.71	$28,002
	R-30 Raised Floor Insulation	(35)	295	1.74	29,364	16.07	$926	$24,654	$4,113	$4,113	5.99	$20,541	8.83	$32,184
	Cool Roof (0.20 Ref) (at roof replacement)	66	(32)	(0.18)	(2,999)	(1.70)	$408	$8,909	$893	$1,203	7.40	$7,705	0.00	($4,683)
	Cool Roof (0.25 Ref) (at roof replacement)	92	(49)	(0.28)	(4,576)	(2.58)	$385	$8,193	$1,786	$2,407	3.40	$5,786	0.00	($7,735)
	Window Upgrade: 0.28 vs 0.35 U-factor	318	183	1.11	19,370	10.30	$805	$20,572	$11,871	$11,871	1.73	$8,701	2.11	$13,120

Table 21: TDPUD Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	30% Air Sealing	39	40	0.24	4,154	2.23	$446	$10,652	$4,684	$4,684	2.27	$5,968	1.11	$527
	New Ducts: R-6	467	187	1.15	20,328	10.79	$761	$19,612	$4,808	$4,808	4.08	$14,803	5.54	$21,815
	New Ducts: R-8	480	197	1.21	21,333	11.33	$779	$20,141	$6,311	$6,311	3.19	$13,830	4.42	$21,578
	Duct Sealing: 10%	368	109	0.68	12,119	6.39	$614	$15,313	$2,590	$2,590	5.91	$12,723	6.24	$13,561
	Wall Insulation: R-13	88	41	0.25	4,389	2.33	$456	$10,889	$2,555	$2,555	4.26	$8,334	2.23	$3,139
	Attic Insulation: R-38	107	51	0.31	5,493	2.91	$476	$11,484	$3,612	$3,612	3.18	$7,872	1.97	$3,515
	Attic Insulation: R-49	19	249	1.47	24,932	13.58	$782	$20,807	$3,633	$3,633	5.73	$17,174	8.48	$27,186
	R-19 Raised Floor Insulation	5	289	1.70	28,891	15.76	$845	$22,725	$4,113	$4,113	5.53	$18,612	8.68	$31,602
	R-30 Raised Floor Insulation	24	(24)	(0.14)	(2,292)	(1.26)	$339	$7,434	$893	$1,203	6.18	$6,231	0.00	($3,917)
	Cool Roof (0.20 Ref) (at roof replacement)	45	(36)	(0.21)	(3,453)	(1.89)	$322	$6,909	$1,786	$2,407	2.87	$4,503	0.00	($6,469)
	Cool Roof (0.25 Ref) (at roof replacement)	88	30	0.18	3,254	1.71	$437	$10,312	$893	$893	11.55	$9,419	4.79	$3,386
	Window Upgrade: 0.28 vs 0.35 U-factor	208	153	0.92	15,975	8.56	$660	$16,907	$11,871	$11,871	1.42	$5,036	1.72	$8,592

Table 22: TDPUD Permanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	30% Air Sealing	25	25	0.15	2,603	1.40	$339	$8,028	$4,684	$4,684	1.71	$3,344	0.70	($1,404)
	New Ducts: R-6	218	51	0.32	5,839	3.06	$413	$10,037	$4,808	$4,808	2.09	$5,229	1.64	$3,100
	New Ducts: R-8	235	61	0.38	6,850	3.60	$432	$10,570	$6,311	$6,311	1.67	$4,259	1.46	$2,896
	Duct Sealing: 10%	35	26	0.15	2,674	1.44	$341	$8,088	$1,400	$1,400	5.78	$6,688	2.44	$2,013
	Attic Insulation: R-38	24	12	0.07	1,255	0.67	$317	$7,370	$1,781	$1,781	4.14	$5,589	0.91	($166)
	Attic Insulation: R-49	46	21	0.13	2,295	1.21	$337	$7,932	$1,827	$1,827	4.34	$6,104	1.62	$1,136
	Cool Roof (0.20 Ref) (at roof replacement)	20	(17)	(0.10)	(1,605)	(0.89)	$270	$5,958	$893	$1,203	4.95	$4,754	0.00	($3,102)
	Cool Roof (0.25 Ref) (at roof replacement)	25	(25)	(0.15)	(2,458)	(1.35)	$257	$5,554	$1,786	$2,407	2.31	$3,148	0.00	($5,321)
	Window Upgrade: 0.28 vs 0.35 U-factor	87	122	0.72	12,453	6.72	$505	$12,972	$11,871	$11,871	1.09	$1,100	1.31	$3,713

Table 23: TDPUD Permanent Rate Solar PV Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	3kW PV	5,173	0	0.14	17,651	1.59	$861	$19,630	$9,608	$11,574	1.70	$8,055	0.92	($868)
1978-1991	3kW PV	4,766	0	0.13	16,264	1.47	$793	$18,087	$9,608	$11,574	1.56	$6,513	0.87	($1,484)
1992-2010	3kW PV	4,266	0	0.12	14,555	1.31	$710	$16,188	$9,608	$11,574	1.40	$4,613	0.81	($2,200)

4.3 Statewide Costs (Nonpermanent Residents)

Table 24: Liberty Nonpermanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	DFHP Existing Furnace	(3,482)	141	0.39	2,217	2.73	($891)	($18,517)	$2,397	$2,341	0.00	($20,857)	0.00	($10,982)
	DFHP New Furnace	(3,482)	137	0.37	1,865	2.53	($897)	($18,701)	$4,757	$6,295	0.00	($24,996)	0.00	($15,370)
	Ducted MSHP	(11,639)	1,252	5.69	85,452	49.20	($1,591)	($20,097)	$2,155	$4,314	0.00	($24,411)	15.33	$61,803
	Ductless MSHP (Std Efficiency)	(10,914)	1,158	5.27	78,572	45.48	($1,520)	($19,681)	$13,336	$21,679	0.00	($41,361)	2.79	$38,843
	Ductless MSHP (High Efficiency)	(6,970)	1,158	5.73	92,028	50.70	($233)	$9,649	$17,266	$28,132	0.34	($18,483)	3.17	$60,912
	HPSH + 3kW PV	(9,536)	1,252	5.38	92,627	45.64	($905)	($4,460)	$12,333	$15,656	0.00	($20,116)	3.62	$40,971
1978-1991	DFHP Existing Furnace	(2,813)	121	0.36	2,528	2.58	($707)	($14,575)	$2,397	$2,341	0.00	($16,916)	0.00	($8,468)
	DFHP New Furnace	(2,813)	118	0.34	2,225	2.42	($712)	($14,734)	$4,757	$6,295	0.00	($21,029)	0.00	($12,789)
	Ducted MSHP	(9,430)	1,013	4.60	69,073	39.72	($1,292)	($16,381)	$2,155	$4,314	0.00	($20,695)	12.36	$48,983
	Ductless MSHP (Std Efficiency)	(8,473)	911	4.16	62,134	35.94	($1,160)	($14,690)	$13,336	$21,679	0.00	($36,369)	2.23	$26,722
	Ductless MSHP (High Efficiency)	(4,448)	911	4.66	75,866	41.61	$153	$15,244	$17,266	$28,132	0.54	($12,888)	2.78	$49,940
	HPSH + 3kW PV	(6,710)	1,013	4.38	78,357	37.19	($405)	$3,854	$12,333	$15,656	0.25	($11,802)	3.07	$32,363
1992-2010	DFHP Existing Furnace	(1,671)	67	0.18	965	1.17	($429)	($8,925)	$2,397	$2,341	0.00	($11,265)	0.00	($6,703)
	DFHP New Furnace	(1,671)	65	0.17	799	1.09	($432)	($9,012)	$4,757	$6,295	0.00	($15,308)	0.00	($10,857)
	Ducted MSHP	(6,049)	661	3.00	45,444	25.94	($807)	($9,850)	$2,155	$4,314	0.00	($14,164)	8.26	$31,301
	Ductless MSHP (Std Efficiency)	(5,357)	588	2.69	40,531	23.26	($710)	($8,576)	$13,336	$21,679	0.00	($30,255)	1.49	$10,522
	Ductless MSHP (High Efficiency)	(2,106)	588	3.13	51,625	28.22	$351	$15,604	$17,266	$28,132	0.55	($12,528)	2.02	$28,595
	HPSH + 3kW PV	(2,554)	661	2.89	57,371	24.68	$333	$16,147	$12,333	$15,656	1.03	$491	2.26	$19,709

Table 25: Liberty Nonpermanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	240V Fed. Min. HPWH	(2,208)	200	0.95	12,427	8.34	($374)	($5,992)	$4,332	$6,554	0.00	($12,546)	1.33	$2,188
	240V Market Std. NEEA HPWH	(2,041)	200	0.97	13,047	8.50	($319)	($4,723)	$5,193	$7,967	0.00	($12,690)	1.24	$1,906
	240V Market Std. NEEA HPWH + DR	(1,846)	200	0.99	13,735	8.76	($255)	($3,256)	$5,193	$7,967	0.00	($11,224)	1.42	$3,372
	120V Market Std. NEEA HPWH	(1,206)	200	1.07	15,865	9.65	($47)	$1,471	$2,893	$4,273	0.34	($2,802)	3.78	$11,878
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,813	8.05	($406)	($6,753)	$4,751	$6,973	0.00	($13,725)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,067)	139	0.72	10,215	6.46	($108)	($708)	$4,413	$6,634	0.00	($7,342)	1.42	$2,806
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,072)	214	1.05	14,306	9.29	($305)	($4,235)	$5,492	$7,714	0.00	($11,948)	1.49	$3,742
	240V Fed. Min. HPWH + 3kW PV	2,964	200	1.09	30,077	9.93	$1,313	$32,480	$13,940	$18,128	1.79	$14,352	1.24	$4,300

Table 26: Liberty Nonpermanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	240V Fed. Min. HPWH	(2,212)	199	0.95	12,328	8.30	($377)	($6,062)	$4,332	$6,554	0.00	($12,616)	1.31	$2,021
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,936	8.45	($322)	($4,804)	$5,193	$7,967	0.00	($12,771)	1.21	$1,690
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,620	8.70	($257)	($3,335)	$5,193	$7,967	0.00	($11,302)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,769	9.61	($49)	$1,409	$2,893	$4,273	0.33	($2,864)	3.74	$11,728
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($406)	($6,753)	$4,751	$6,973	0.00	($13,725)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,090)	143	0.74	10,563	6.68	($108)	($651)	$4,413	$6,634	0.00	($7,285)	1.48	$3,156
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,063)	214	1.05	14,327	9.30	($302)	($4,172)	$5,492	$7,714	0.00	($11,885)	1.48	$3,725
	240V Fed. Min. HPWH + 3kW PV	2,961	199	1.09	29,978	9.89	$1,311	$32,411	$13,940	$18,128	1.79	$14,283	1.22	$3,917

Table 27: Liberty Nonpermanent Rate HPWH Single Family Cost-Effectiveness

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	240V Fed. Min. HPWH	(2,213)	199	0.95	12,314	8.30	($377)	($6,075)	$4,332	$6,554	0.00	($12,629)	1.31	$2,004
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,919	8.44	($322)	($4,812)	$5,193	$7,967	0.00	($12,779)	1.21	$1,673
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,599	8.70	($258)	($3,349)	$5,193	$7,967	0.00	($11,316)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,742	9.60	($50)	$1,394	$2,893	$4,273	0.33	($2,879)	3.74	$11,711
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($406)	($6,753)	$4,751	$6,973	0.00	($13,725)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,087)	151	0.79	11,342	7.10	($94)	($225)	$4,413	$6,634	0.00	($6,859)	1.62	$4,122
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,056)	213	1.04	14,230	9.25	($302)	($4,185)	$5,492	$7,714	0.00	($11,898)	1.47	$3,658
	240V Fed. Min. HPWH + 3kW PV	2,960	199	1.09	29,965	9.89	$1,310	$32,397	$13,940	$18,128	1.79	$14,269	1.20	$3,634

Table 28: Liberty Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary Pre1978

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	30% Air Sealing	62	66	0.39	6,790	3.63	$136	$3,951	$4,684	$4,684	0.84	($733)	1.83	$3,891
	New Ducts: R-6	635	260	1.60	28,202	14.95	$666	$18,556	$4,808	$4,808	3.86	$13,748	7.67	$32,071
	New Ducts: R-8	653	270	1.66	29,236	15.49	$689	$19,205	$6,311	$6,311	3.04	$12,894	6.05	$31,901
	Duct Sealing: 10%	246	186	1.12	19,478	10.41	$409	$11,730	$2,590	$2,590	4.53	$9,140	9.61	$22,302
	Wall Insulation: R-13	162	159	0.95	16,413	8.79	$332	$9,603	$2,950	$2,950	3.25	$6,653	7.02	$17,762
	Attic Insulation: R-38	267	116	0.70	12,481	6.56	$292	$8,164	$6,762	$6,762	1.21	$1,402	2.40	$9,438
	Attic Insulation: R-49	295	127	0.78	13,741	7.22	$322	$8,996	$7,446	$7,446	1.21	$1,550	2.40	$10,419
	R-19 Raised Floor Insulation	(19)	257	1.51	25,579	13.97	$442	$13,359	$3,633	$3,633	3.68	$9,726	8.71	$28,002
	R-30 Raised Floor Insulation	(35)	295	1.74	29,364	16.07	$504	$15,267	$4,113	$4,113	3.71	$11,154	8.83	$32,184
	Cool Roof (0.20 Ref) (at roof replacement)	66	(32)	(0.18)	(2,999)	(1.70)	($34)	($1,193)	$893	$1,203	0.00	($2,397)	0.00	($4,683)
	Cool Roof (0.25 Ref) (at roof replacement)	92	(49)	(0.28)	(4,576)	(2.58)	($55)	($1,871)	$1,786	$2,407	0.00	($4,278)	0.00	($7,735)
	Window Upgrade: 0.28 vs 0.35 U-factor	318	183	1.11	19,370	10.30	$427	$12,102	$11,871	$11,871	1.02	$231	2.11	$13,120

Table 29: Liberty Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	30% Air Sealing	39	40	0.24	4,154	2.23	$83	$2,422	$4,684	$4,684	0.52	($2,262)	1.11	$527
	New Ducts: R-6	467	187	1.15	20,328	10.79	$483	$13,426	$4,808	$4,808	2.79	$8,618	5.54	$21,815
	New Ducts: R-8	480	197	1.21	21,333	11.33	$504	$14,036	$6,311	$6,311	2.22	$7,725	4.42	$21,578
	Duct Sealing: 10%	368	109	0.68	12,119	6.39	$311	$8,507	$2,590	$2,590	3.28	$5,917	6.24	$13,561
	Attic Insulation: R-38	88	41	0.25	4,389	2.33	$101	$2,840	$2,555	$2,555	1.11	$284	2.23	$3,139
	Attic Insulation: R-49	107	51	0.31	5,493	2.91	$126	$3,540	$3,612	$3,612	0.98	($71)	1.97	$3,515
	R-19 Raised Floor Insulation	19	249	1.47	24,932	13.58	$440	$13,228	$3,633	$3,633	3.64	$9,595	8.48	$27,186
	R-30 Raised Floor Insulation	5	289	1.70	28,891	15.76	$506	$15,239	$4,113	$4,113	3.71	$11,127	8.68	$31,602
	Cool Roof (0.20 Ref) (at roof replacement)	24	(24)	(0.14)	(2,292)	(1.26)	($33)	($1,060)	$893	$1,203	0.00	($2,263)	0.00	($3,917)
	Cool Roof (0.25 Ref) (at roof replacement)	45	(36)	(0.21)	(3,453)	(1.89)	($48)	($1,551)	$1,786	$2,407	0.00	($3,958)	0.00	($6,469)
	Window Upgrade: 0.28 vs 0.35 U-factor	208	153	0.92	15,975	8.56	$337	$9,664	$11,871	$11,871	0.81	($2,207)	1.72	$8,592

Table 30: Liberty Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	30% Air Sealing	25	25	0.15	2,603	1.40	$52	$1,522	$4,684	$4,684	0.32	($3,163)	0.70	($1,404)
	New Ducts: R-6	218	51	0.32	5,839	3.06	$161	$4,335	$4,808	$4,808	0.90	($473)	1.64	$3,100
	New Ducts: R-8	235	61	0.38	6,850	3.60	$183	$4,965	$6,311	$6,311	0.79	($1,346)	1.46	$2,896
	Duct Sealing: 10%	35	26	0.15	2,674	1.44	$56	$1,619	$1,400	$1,400	1.16	$218	2.44	$2,013
	Attic Insulation: R-38	24	12	0.07	1,255	0.67	$29	$807	$1,781	$1,781	0.45	($975)	0.91	($166)
	Attic Insulation: R-49	46	21	0.13	2,295	1.21	$53	$1,485	$1,827	$1,827	0.81	($342)	1.62	$1,136
	Cool Roof (0.20 Ref) (at roof replacement)	20	(17)	(0.10)	(1,605)	(0.89)	($23)	($726)	$893	$1,203	0.00	($1,930)	0.00	($3,102)
	Cool Roof (0.25 Ref) (at roof replacement)	25	(25)	(0.15)	(2,458)	(1.35)	($36)	($1,144)	$1,786	$2,407	0.00	($3,551)	0.00	($5,321)
	Window Upgrade: 0.28 vs 0.35 U-factor	87	122	0.72	12,453	6.72	$242	$7,076	$11,871	$11,871	0.60	($4,796)	1.31	$3,713

Table 31: Liberty Nonpermanent Rate Solar PV Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	3kW PV	5,173	0	0.14	17,651	1.59	$1,688	$38,473	$9,608	$11,574	3.32	$26,898	0.92	($868)
1978-1991	3kW PV	4,766	0	0.13	16,264	1.47	$1,555	$35,450	$9,608	$11,574	3.06	$23,876	0.87	($1,484)
1992-2010	3kW PV	4,266	0	0.12	14,555	1.31	$1,392	$31,726	$9,608	$11,574	2.74	$20,152	0.81	($2,200)

Table 32: TDPUD Nonpermanent Rate HPSH Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	DFHP Existing Furnace	(3,482)	141	0.39	2,217	2.73	($414)	($7,652)	$2,397	$2,341	0.00	($9,992)	0.00	($10,982)
	DFHP New Furnace	(3,482)	137	0.37	1,865	2.53	($421)	($7,836)	$4,757	$6,295	0.00	($14,132)	0.00	($15,370)
	Ducted MSHP	(11,639)	1,252	5.69	85,452	49.20	$2	$16,221	$2,155	$4,314	3.76	$11,907	15.33	$61,803
	Ductless MSHP (Std Efficiency)	(10,914)	1,158	5.27	78,572	45.48	($26)	$14,374	$13,336	$21,679	0.66	($7,305)	2.79	$38,843
	Ductless MSHP (High Efficiency)	(6,970)	1,158	5.73	92,028	50.70	$721	$31,398	$17,266	$28,132	1.12	$3,267	3.17	$60,912
	HPSH + 3kW PV	(9,536)	1,252	5.38	92,627	45.64	$400	$25,297	$12,333	$15,656	1.62	$9,641	3.62	$40,971
1978-1991	DFHP Existing Furnace	(2,813)	121	0.36	2,528	2.58	($322)	($5,797)	$2,397	$2,341	0.00	($8,138)	0.00	($8,468)
	DFHP New Furnace	(2,813)	118	0.34	2,225	2.42	($327)	($5,956)	$4,757	$6,295	0.00	($12,251)	0.00	($12,789)
	Ducted MSHP	(9,430)	1,013	4.60	69,073	39.72	($2)	$13,046	$2,155	$4,314	3.02	$8,732	12.36	$48,983
	Ductless MSHP (Std Efficiency)	(8,473)	911	4.16	62,134	35.94	($1)	$11,749	$13,336	$21,679	0.54	($9,931)	2.23	$26,722
	Ductless MSHP (High Efficiency)	(4,448)	911	4.66	75,866	41.61	$761	$29,123	$17,266	$28,132	1.04	$992	2.78	$49,940
	HPSH + 3kW PV	(6,710)	1,013	4.38	78,357	37.19	$513	$24,791	$12,333	$15,656	1.58	$9,135	3.07	$32,363
1992-2010	DFHP Existing Furnace	(1,671)	67	0.18	965	1.17	($200)	($3,712)	$2,397	$2,341	0.00	($6,052)	0.00	($6,703)
	DFHP New Furnace	(1,671)	65	0.17	799	1.09	($203)	($3,799)	$4,757	$6,295	0.00	($10,095)	0.00	($10,857)
	Ducted MSHP	(6,049)	661	3.00	45,444	25.94	$21	$9,026	$2,155	$4,314	2.09	$4,713	8.26	$31,301
	Ductless MSHP (Std Efficiency)	(5,357)	588	2.69	40,531	23.26	$23	$8,139	$13,336	$21,679	0.38	($13,540)	1.49	$10,522
	Ductless MSHP (High Efficiency)	(2,106)	588	3.13	51,625	28.22	$639	$22,175	$17,266	$28,132	0.79	($5,957)	2.02	$28,595
	HPSH + 3kW PV	(2,554)	661	2.89	57,371	24.68	$683	$24,116	$12,333	$15,656	1.54	$8,460	2.26	$19,709

Table 33: TDPUD Nonpermanent Rate HPWH Single Family Cost-Effectiveness Pre1978

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	240V Fed. Min. HPWH	(2,208)	200	0.95	12,427	8.34	($72)	$899	$4,332	$6,554	0.14	($5,655)	1.33	$2,188
	240V Market Std. NEEA HPWH	(2,041)	200	0.97	13,047	8.50	($39)	$1,647	$5,193	$7,967	0.21	($6,320)	1.24	$1,906
	240V Market Std. NEEA HPWH + DR	(1,846)	200	0.99	13,735	8.76	($2)	$2,503	$5,193	$7,967	0.31	($5,464)	1.42	$3,372
	120V Market Std. NEEA HPWH	(1,206)	200	1.07	15,865	9.65	$118	$5,234	$2,893	$4,273	1.23	$962	3.78	$11,878
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,813	8.05	($93)	$381	$4,751	$6,973	0.05	($6,592)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,067)	139	0.72	10,215	6.46	$38	$2,622	$4,413	$6,634	0.40	($4,013)	1.42	$2,806
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,072)	214	1.05	14,306	9.29	($21)	$2,231	$5,492	$7,714	0.29	($5,483)	1.49	$3,742
	240V Fed. Min. HPWH + 3kW PV	2,964	200	1.09	30,077	9.93	$908	$23,230	$13,940	$18,128	1.28	$5,102	1.24	$4,300

Table 34: TDPUD Nonpermanent Rate HPWH Single Family Cost-Effectiveness 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	240V Fed. Min. HPWH	(2,212)	199	0.95	12,328	8.30	($74)	$839	$4,332	$6,554	0.13	($5,715)	1.31	$2,021
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,936	8.45	($42)	$1,578	$5,193	$7,967	0.20	($6,389)	1.21	$1,690
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,620	8.70	($4)	$2,434	$5,193	$7,967	0.31	($5,533)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,769	9.61	$116	$5,179	$2,893	$4,273	1.21	$906	3.74	$11,728
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($93)	$381	$4,751	$6,973	0.05	($6,592)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,090)	143	0.74	10,563	6.68	$41	$2,749	$4,413	$6,634	0.41	($3,885)	1.48	$3,156
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,063)	214	1.05	14,327	9.30	($20)	$2,265	$5,492	$7,714	0.29	($5,449)	1.48	$3,725
	240V Fed. Min. HPWH + 3kW PV	2,961	199	1.09	29,978	9.89	$905	$23,170	$13,940	$18,128	1.28	$5,042	1.22	$3,917

Table 35: TDPUD Nonpermanent Rate HPWH Single Family Cost-Effectiveness 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	240V Fed. Min. HPWH	(2,213)	199	0.95	12,314	8.30	($74)	$829	$4,332	$6,554	0.13	($5,725)	1.31	$2,004
	240V Market Std. NEEA HPWH	(2,045)	199	0.96	12,919	8.44	($42)	$1,570	$5,193	$7,967	0.20	($6,397)	1.21	$1,673
	240V Market Std. NEEA HPWH + DR	(1,849)	199	0.98	13,599	8.70	($5)	$2,421	$5,193	$7,967	0.30	($5,546)	1.40	$3,155
	120V Market Std. NEEA HPWH	(1,208)	199	1.06	15,742	9.60	$116	$5,165	$2,893	$4,273	1.21	$892	3.74	$11,711
	240V Fed. Min. HPWH (Exterior Closet)	(2,286)	196	0.92	11,814	8.05	($93)	$381	$4,751	$6,973	0.05	($6,592)	1.10	$703
	240V Fed. Min. HPWH (Interior Closet)	(1,087)	151	0.79	11,342	7.10	$55	$3,166	$4,413	$6,634	0.48	($3,468)	1.62	$4,122
	240V Fed. Min. HPWH (Interior Closet, ducted)	(2,056)	213	1.04	14,230	9.25	($21)	$2,231	$5,492	$7,714	0.29	($5,482)	1.47	$3,658
	240V Fed. Min. HPWH + 3kW PV	2,960	199	1.09	29,965	9.89	$905	$23,160	$13,940	$18,128	1.28	$5,032	1.20	$3,634

Table 36: TDPUD Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary Pre1978

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	30% Air Sealing	62	66	0.39	6,790	3.63	$128	$3,757	$4,684	$4,684	0.80	($927)	1.83	$3,891
	New Ducts: R-6	635	260	1.60	28,202	14.95	$579	$16,575	$4,808	$4,808	3.45	$11,766	7.67	$32,071
	New Ducts: R-8	653	270	1.66	29,236	15.49	$600	$17,168	$6,311	$6,311	2.72	$10,857	6.05	$31,901
	Duct Sealing: 10%	246	186	1.12	19,478	10.41	$375	$10,963	$2,590	$2,590	4.23	$8,374	9.61	$22,302
	Wall Insulation: R-13	162	159	0.95	16,413	8.79	$309	$9,097	$2,950	$2,950	3.08	$6,146	7.02	$17,762
	Attic Insulation: R-38	267	116	0.70	12,481	6.56	$256	$7,331	$6,762	$6,762	1.08	$569	2.40	$9,438
	Attic Insulation: R-49	295	127	0.78	13,741	7.22	$282	$8,074	$7,446	$7,446	1.08	$628	2.40	$10,419
	R-19 Raised Floor Insulation	(19)	257	1.51	25,579	13.97	$444	$13,419	$3,633	$3,633	3.69	$9,786	8.71	$28,002
	R-30 Raised Floor Insulation	(35)	295	1.74	29,364	16.07	$509	$15,374	$4,113	$4,113	3.74	$11,262	8.83	$32,184
	Cool Roof (0.20 Ref) (at roof replacement)	66	(32)	(0.18)	(2,999)	(1.70)	($43)	($1,399)	$893	$1,203	0.00	($2,602)	0.00	($4,683)
	Cool Roof (0.25 Ref) (at roof replacement)	92	(49)	(0.28)	(4,576)	(2.58)	($67)	($2,157)	$1,786	$2,407	0.00	($4,564)	0.00	($7,735)
	Window Upgrade: 0.28 vs 0.35 U-factor	318	183	1.11	19,370	10.30	$383	$11,109	$11,871	$11,871	0.94	($762)	2.11	$13,120

Table 37: TDPUD Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1978-1991

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft^2)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1978-1991	30% Air Sealing	39	40	0.24	4,154	2.23	$78	$2,301	$4,684	$4,684	0.49	($2,383)	1.11	$527
	New Ducts: R-6	467	187	1.15	20,328	10.79	$419	$11,970	$4,808	$4,808	2.49	$7,161	5.54	$21,815
	New Ducts: R-8	480	197	1.21	21,333	11.33	$438	$12,538	$6,311	$6,311	1.99	$6,226	4.42	$21,578
	Duct Sealing: 10%	368	109	0.68	12,119	6.39	$261	$7,359	$2,590	$2,590	2.84	$4,770	6.24	$13,561
	Attic Insulation: R-38	88	41	0.25	4,389	2.33	$89	$2,566	$2,555	$2,555	1.00	$11	2.23	$3,139
	Attic Insulation: R-49	107	51	0.31	5,493	2.91	$111	$3,206	$3,612	$3,612	0.89	($406)	1.97	$3,515
	R-19 Raised Floor Insulation	19	249	1.47	24,932	13.58	$438	$13,170	$3,633	$3,633	3.63	$9,537	8.48	$27,186
	R-30 Raised Floor Insulation	5	289	1.70	28,891	15.76	$505	$15,223	$4,113	$4,113	3.70	$11,111	8.68	$31,602
	Cool Roof (0.20 Ref) (at roof replacement)	24	(24)	(0.14)	(2,292)	(1.26)	($37)	($1,136)	$893	$1,203	0.00	($2,339)	0.00	($3,917)
	Cool Roof (0.25 Ref) (at roof replacement)	45	(36)	(0.21)	(3,453)	(1.89)	($54)	($1,691)	$1,786	$2,407	0.00	($4,098)	0.00	($6,469)
	Window Upgrade: 0.28 vs 0.35 U-factor	208	153	0.92	15,975	8.56	$309	$9,017	$11,871	$11,871	0.76	($2,855)	1.72	$8,592

Table 38: TDPUD Nonpermanent Rate Envelope and Duct Measures Single Family Cost-Effectiveness Summary 1992-2010

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
1992-2010	30% Air Sealing	25	25	0.15	2,603	1.40	$49	$1,443	$4,684	$4,684	0.31	($3,241)	0.70	($1,404)
	New Ducts: R-6	218	51	0.32	5,839	3.06	$131	$3,654	$4,808	$4,808	0.76	($1,155)	1.64	$3,100
	New Ducts: R-8	235	61	0.38	6,850	3.60	$151	$4,233	$6,311	$6,311	0.67	($2,078)	1.46	$2,896
	Duct Sealing: 10%	35	26	0.15	2,674	1.44	$52	$1,510	$1,400	$1,400	1.08	$110	2.44	$2,013
	Attic Insulation: R-38	24	12	0.07	1,255	0.67	$25	$731	$1,781	$1,781	0.41	($1,050)	0.91	($166)
	Attic Insulation: R-49	46	21	0.13	2,295	1.21	$47	$1,341	$1,827	$1,827	0.73	($486)	1.62	$1,136
	Cool Roof (0.20 Ref) (at roof replacement)	20	(17)	(0.10)	(1,605)	(0.89)	($25)	($789)	$893	$1,203	0.00	($1,992)	0.00	($3,102)
	Cool Roof (0.25 Ref) (at roof replacement)	25	(25)	(0.15)	(2,458)	(1.35)	($39)	($1,222)	$1,786	$2,407	0.00	($3,629)	0.00	($5,321)
	Window Upgrade: 0.28 vs 0.35 U-factor	87	122	0.72	12,453	6.72	$230	$6,806	$11,871	$11,871	0.57	($5,066)	1.31	$3,713

Table 39: TDPUD Nonpermanent Rate Solar PV Single Family Cost-Effectiveness Summary

Vintage Year	Case	Annual Elec Savings (kWh)	Annual Gas Savings (therms)	Average Annual GHG Reductions (metric tons)	Annual Site Energy (kBtu)	Annual Source Energy (kBtu/ft²)	Utility Cost Savings		Incremental Cost		On-Bill		2025 LSC	
							First Year	Lifecycle (2022$)	First Year	Lifecycle (2022$)	B/C Ratio	NPV	B/C Ratio	NPV
Pre1978	3kW PV	5,173	0	0.14	17,651	1.59	$980	$22,331	$9,608	$11,574	1.93	$10,757	0.92	($868)
1978-1991	3kW PV	4,766	0	0.13	16,264	1.47	$903	$20,577	$9,608	$11,574	1.78	$9,002	0.87	($1,484)
1992-2010	3kW PV	4,266	0	0.12	14,555	1.31	$808	$18,415	$9,608	$11,574	1.59	$6,841	0.81	($2,200)

4.4 Sensitivities

Table 40 and Table 41 shows the results that use Truckee measure costs to evaluate On-Bill NPV with Liberty and TDPUD rates, respectively, and the impacts of escalation rates for select cases. Table 42 and Table 43 shows the results that use Statewide measure costs to evaluate On-Bill NPV with Liberty and TDPUD rates, respectively, and the impacts of escalation rates for select cases. The "Standard Results (Permanent Residents)" and "Standard Results (Nonpermanent Residents)" in Table 40 through Table 43 assumes the escalation rates used in the analysis presented elsewhere in this report. Table 44 and Table 45 shows the impact of electrical panel upgrades with Truckee costs for permanent and nonpermanent residents, respectively. Table 46 and Table 47 shows the impact of electrical panel upgrades with statewide reach codes costs for permanent and nonpermanent residents, respectively. The "Standard Results" in Table 44 through Table 47 does not assume a panel upgrade is required. The cases in Table 44 through Table 47 are based on the escalation rates used in the analysis presented elsewhere in this report.

Table 40. Truckee Costs: Liberty Sensitivity Analysis Results for On-Bill NPV

Measure	Vintage	Standard Results (Permanent Residents)	2025 LSC Escalation (Permanent Residents)	Standard Results (Nonpermanent Residents)	2025 LSC Escalation (Nonpermanent Residents)
HPSH (Std Efficiency)	1992-2010	($26,175)	($9,288)	($22,821)	($3,404)
HPSH (High Efficiency)	1992-2010	($21,596)	($4,020)	($18,835)	$1,240
HPSH (Std Efficiency)	1978-1991	($41,476)	($15,215)	($35,114)	($5,435)
HPSH (High Efficiency)	1978-1991	($30,849)	($3,581)	($25,364)	$5,276

Table 41. Truckee Costs: TDPUD Sensitivity Analysis Results for On-Bill NPV

Measure	Vintage	Standard Results (Permanent Residents)	2025 LSC Escalation (Permanent Residents)	Standard Results (Nonpermanent Residents)	2025 LSC Escalation (Nonpermanent Residents)
HPSH (Std Efficiency)	1992-2010	$1,307	$19,640	$1,289	$21,975
HPSH (High Efficiency)	1992-2010	($828)	$17,840	$32	$21,100
HPSH (Std Efficiency)	1978-1991	$2,908	$31,504	$1,964	$33,594
HPSH (High Efficiency)	1978-1991	$3,714	$32,800	$4,053	$36,240

Table 42. Statewide Costs: Liberty Sensitivity Analysis Results for On-Bill NPV

Measure	Vintage	Standard Results (Permanent Residents)	2025 LSC Escalation (Permanent Residents)	Standard Results (Nonpermanent Residents)	2025 LSC Escalation (Nonpermanent Residents)
DFHP Existing Furnace	1992-2010	($10,631)	($9,189)	($11,265)	($9,684)
DFHP New Furnace	1992-2010	($14,666)	($13,275)	($15,308)	($13,782)
Ducted MSHP	1992-2010	($16,923)	$652	($14,164)	$5,910
HPSH + 3kW PV	1992-2010	($11,933)	$4,395	($8,171)	$10,543
240V Fed. Min. HPWH	1992-2010	($12,931)	($7,762)	($12,629)	($6,865)
240V Market Std. NEEA HPWH	1992-2010	($13,090)	($7,845)	($12,779)	($6,939)
240V Market Std. NEEA HPWH + DR	1992-2010	($11,644)	($6,319)	($11,316)	($5,396)
120V Market Std. NEEA HPWH	1992-2010	($3,235)	$2,324	($2,879)	$3,278
240V Fed. Min. HPWH (Exterior Closet)	1992-2010	($14,029)	($8,967)	($13,725)	($8,075)
240V Fed. Min. HPWH (Interior Closet)	1992-2010	($7,020)	($2,884)	($6,859)	($2,266)
240V Fed. Min. HPWH (Interior Closet, ducted)	1992-2010	($12,215)	($6,557)	($11,898)	($5,610)
240V Fed. Min. HPWH + 3kW PV	1992-2010	$11,635	$18,705	$14,269	$22,057
DFHP Existing Furnace	1978-1991	($15,831)	($13,070)	($16,916)	($13,963)
DFHP New Furnace	1978-1991	($19,939)	($17,275)	($21,029)	($18,178)
HPSH (Std Efficiency)	1978-1991	($41,476)	($15,215)	($35,114)	($5,435)
HPSH (High Efficiency)	1978-1991	($30,849)	($3,581)	($25,364)	$5,276
Ducted MSHP	1978-1991	($26,178)	$1,088	($20,695)	$9,944
HPSH + 3kW PV	1978-1991	($18,349)	$9,927	($11,802)	$19,901
240V Fed. Min. HPWH	1978-1991	($13,170)	($7,912)	($12,616)	($6,848)
240V Market Std. NEEA HPWH	1978-1991	($13,330)	($7,995)	($12,771)	($6,925)
240V Market Std. NEEA HPWH + DR	1978-1991	($11,830)	($6,412)	($11,302)	($5,375)
120V Market Std. NEEA HPWH	1978-1991	($3,278)	$2,385	($2,864)	$3,301
240V Fed. Min. HPWH (Exterior Closet)	1978-1991	($14,282)	($9,135)	($13,725)	($8,075)
240V Fed. Min. HPWH (Interior Closet)	1978-1991	($7,407)	($3,431)	($7,285)	($2,952)
240V Fed. Min. HPWH (Interior Closet, ducted)	1978-1991	($12,451)	($6,670)	($11,885)	($5,560)
240V Fed. Min. HPWH + 3kW PV	1978-1991	$11,814	$18,995	$14,283	$22,074
30% Air Sealing	Pre-1978	($986)	$1,125	($733)	$1,519
R-6 Ducts	Pre-1978	$12,534	$21,048	$13,748	$22,830
R-8 Ducts	Pre-1978	$11,638	$20,469	$12,894	$22,314
10% Duct Sealing	Pre-1978	$8,388	$14,407	$9,140	$15,560
R-13 Wall Insulation	Pre-1978	$6,037	$11,123	$6,653	$12,078
R-38 Attic Insulation	Pre-1978	$870	$4,666	$1,402	$5,452
R-49 Attic Insulation	Pre-1978	$963	$5,142	$1,550	$6,008
R-30 Raised Floor Insulation	Pre-1978	$10,171	$19,449	$11,154	$21,054
Cool Roof (0.20 Ref) (at roof replacement)	Pre-1978	($2,326)	($3,309)	($2,397)	($3,446)

Table 43. Statewide Costs: TDPUD Sensitivity Analysis Results for On-Bill NPV

Measure	Vintage	Standard Results (Permanent Residents)	2025 LSC Escalation (Permanent Residents)	Standard Results (Nonpermanent Residents)	2025 LSC Escalation (Nonpermanent Residents)
DFHP Existing Furnace	1992-2010	($5,475)	($3,763)	($6,052)	($4,196)
DFHP New Furnace	1992-2010	($9,510)	($7,849)	($10,095)	($8,295)
Ducted MSHP	1992-2010	$3,854	$22,522	$4,713	$25,780
HPSH + 3kW PV	1992-2010	$5,776	$25,142	$8,460	$30,321
240V Fed. Min. HPWH	1992-2010	($5,556)	$2	($5,725)	$402
240V Market Std. NEEA HPWH	1992-2010	($6,317)	($716)	($6,397)	($221)
240V Market Std. NEEA HPWH + DR	1992-2010	($5,569)	$75	($5,546)	$679
120V Market Std. NEEA HPWH	1992-2010	$535	$6,293	$892	$7,247
240V Fed. Min. HPWH (Exterior Closet)	1992-2010	($6,375)	($909)	($6,592)	($566)
240V Fed. Min. HPWH (Interior Closet)	1992-2010	($3,666)	$647	($3,468)	$1,303
240V Fed. Min. HPWH (Interior Closet, ducted)	1992-2010	($5,457)	$557	($5,482)	$1,144
240V Fed. Min. HPWH + 3kW PV	1992-2010	$2,500	$9,090	$5,032	$12,334
DFHP Existing Furnace	1978-1991	($7,092)	($3,871)	($8,138)	($4,723)
DFHP New Furnace	1978-1991	($11,199)	($8,076)	($12,251)	($8,938)
HPSH (Std Efficiency)	1978-1991	$2,908	$31,504	$1,964	$33,594
HPSH (High Efficiency)	1978-1991	$3,714	$32,800	$4,053	$36,240
Ducted MSHP	1978-1991	$8,395	$37,480	$8,732	$40,919
HPSH + 3kW PV	1978-1991	$7,377	$37,006	$9,135	$41,940
240V Fed. Min. HPWH	1978-1991	($5,380)	$288	($5,715)	$416
240V Market Std. NEEA HPWH	1978-1991	($6,142)	($429)	($6,389)	($208)
240V Market Std. NEEA HPWH + DR	1978-1991	($5,390)	$367	($5,533)	$698
120V Market Std. NEEA HPWH	1978-1991	$716	$6,589	$906	$7,270
240V Fed. Min. HPWH (Exterior Closet)	1978-1991	($6,208)	($637)	($6,592)	($566)
240V Fed. Min. HPWH (Interior Closet)	1978-1991	($3,916)	$243	($3,885)	$628
240V Fed. Min. HPWH (Interior Closet, ducted)	1978-1991	($5,251)	$908	($5,449)	$1,216
240V Fed. Min. HPWH + 3kW PV	1978-1991	$2,676	$9,376	$5,042	$12,347
30% Air Sealing	Pre-1978	($1,178)	$923	($927)	$416
R-6 Ducts	Pre-1978	$10,574	$18,985	$11,766	$1,315
R-8 Ducts	Pre-1978	$9,624	$18,349	$10,857	$20,744
10% Duct Sealing	Pre-1978	$7,630	$13,609	$8,374	$20,170
R-13 Wall Insulation	Pre-1978	$5,537	$10,595	$6,146	$14,753
R-38 Attic Insulation	Pre-1978	$45	$3,799	$569	$11,545
R-49 Attic Insulation	Pre-1978	$52	$4,183	$628	$4,574
R-30 Raised Floor Insulation	Pre-1978	$10,306	$19,591	$11,262	$21,167
Cool Roof (0.20 Ref) (at roof replacement)	Pre-1978	($2,530)	($3,523)	($2,602)	($3,662)

Table 44. Truckee Costs: Electric Panel Upgrade Sensitivity [Pre-1978] Permanent

Utility Rate	Measure	Standard Results		Electric Panel Upgrade	
		On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
Liberty	HPSH (Std Efficiency)	($51,834)	$41,928	($58,200)	$35,562
TDPUD	HPSH (Std Efficiency)	$4,098	$41,928	($2,268)	$35,562

Table 45. Truckee Costs: Electric Panel Upgrade Sensitivity [Pre-1978] Nonpermanent

Utility Rate	Measure	Standard Results		Electric Panel Upgrade	
		On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
Liberty	HPSH (Std Efficiency)	($43,428)	$41,928	($49,794)	$35,562
TDPUD	HPSH (Std Efficiency)	$2,470	$41,928	($3,896)	$35,562

Table 46. Statewide Costs: Electric Panel Upgrade Sensitivity [Pre-1978] Permanent

Utility Rate	Measure	Standard Results		Electric Panel Upgrade	
		On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
Liberty	240V Fed. Min. HPWH	($13,361)	$2,188	($16,141)	($592)
TDPUD	240V Fed. Min. HPWH	($5,268)	$2,188	($8,048)	($592)

Table 47. Statewide Costs: Electric Panel Upgrade Sensitivity [Pre-1978] Nonpermanent

Utility Rate	Measure	Standard Results		Electric Panel Upgrade	
		On-Bill NPV	LSC NPV	On-Bill NPV	LSC NPV
Liberty	240V Fed. Min. HPWH	($12,546)	$2,188	($15,326)	($592)
TDPUD	HPSH (Std Efficiency)	$2,470	$41,928	($3,896)	$35,562

5 Summary

This analysis evaluated the feasibility and cost-effectiveness of retrofit measures in California existing homes built before 2010. The Statewide Reach Codes Team used both On-Bill and LSC-based LCC approaches to evaluate cost-effectiveness and quantify the energy cost savings associated with energy efficiency measures compared to the incremental costs associated with the measures.

Conclusions and Discussion:

1. Heat pump space heating: HPSHs were found to be LSC cost-effective in all cases with exception to DFHP Existing Furnace and DFHP New Furnace cases all for all three vintages for permanent and nonpermanent resident rates. The HPSH cases were not found to be On-Bill cost-effective for the Liberty rate with exception to the HPSH +3kW PV measure for the nonpermanent resident rate for 1992-2010 vintage. HPSH cases were On-Bill cost-effective with TDPUD permanent and nonpermanent rates for HPSH (Std Efficiency), HPSH (High Efficiency), Ducted MSHP and HPSH + 3kW PV for all 3 vintages. The Ductless MSHP (High Efficiency) also was found to be cost effective with the TDPUD permanent and nonpermanent resident rates for the pre1978 vintage.
    a. Challenges to On-Bill cost-effectiveness include higher first costs and higher first-year utility costs due to higher electricity tariffs relative to gas tariffs.
    b. Ductless MSHPs, evaluated for homes with existing ductless systems, have a high incremental cost because they are a more sophisticated system than the base model of a wall furnace with a window AC unit. However, the ductless MSHP would provide greater comfort benefits if properly installed to directly condition all habitable spaces (as is required under the VCHP compliance credit as evaluated in this study) which may be an incentive for a homeowner to upgrade their system.
    c. Higher efficiency equipment lowered utility costs in all cases and improved cost-effectiveness in many cases, particularly with a ducted MSHP.
2. Heat pump water heating: All the HPWH measures were LSC cost-effective for all three vintages for permanent and nonpermanent resident rates. The 120V Market Std. NEEA HPWH and the 240V Fed. Min. HPWH + 3kW PV were found to be cost-effective On-Bill for the Liberty and TDPUD permanent and nonpermanent resident rates for all three vintages. The 120V Market Std. NEEA HPWH was also found to be On-Bill cost-effective for the TDPUD permanent and nonpermanent resident rates for all three vintages. The HPWH measures share many of the same challenges as the HPSH measures to achieving cost-effectiveness including high first costs and utility rates and assumptions.
    a. Various HPWH locations were also explored, however there are some factors outside of cost-effectiveness that should also be considered.
        i. HPWHs in the conditioned space can provide benefits such as free-cooling during the summer, reduced tank losses, and shorter pipe lengths, and in some cases show improved cost-effectiveness over garage located HPWHs. However, there are various design considerations such as noise, comfort concerns including unwanted cooling in the winter, and condensate removal. Ducting the inlet and exhaust air resolves comfort concerns but adds costs and complexity. Split heat pump water heaters address these concerns, but currently there are limited products on the market and there is a cost premium relative to the packaged products.
        ii. Since HPWHs extract heat from the air and transfer it to water in the storage tank, they must have adequate ventilation to operate properly. Otherwise, the space cools down over time, impacting the HPWH operating efficiency. This is not a problem with garage installations but needs to be considered for water heaters located in interior or exterior closets. For the 2025 Title 24 code the CEC is proposing that all HPWH installations meet mandatory ventilation requirements (California Energy Commission, 2023).
3. Envelope measures: All envelope measures were found to be LSC cost-effective, with the exception of Cool Roofs for all three vintages, 30% Air Sealing, Attic Insulation: R-38 and Window Upgrade: 0.28 vs 0.35 U-factor

for 1992-2010 vintage for permanent and nonpermanent resident rates. All envelope measures were found to be On-Bill cost-effective with exception to the 30% Air Sealing Attic, and Cool Roofs for all three vintages, Insulation: R-38 and Window Upgrade: 0.28 vs 0.35 U-factor measures for the 1978-1991 and 1992-2010 vintages and New Ducts: R-6, New Ducts: R-8 and Attic Insulation: R-49 for the 1992 vintage for Liberty permanent and nonpermanent resident rates. For the TDPUD All envelope measures were found to be On-Bill cost-effective for the TDPUD permanent and nonpermanent rates with the exception of the Window Upgrade: 0.28 vs 0.35 U-factor for 1992-2010 vintage. In addition to reducing utility costs these measures provide many other benefits such as improving occupant comfort and satisfaction and increasing a home's ability to maintain temperatures during extreme weather events and power outages. Below is a discussion of the results of specific measures for all three vintages.

   a. Adding new ducts with R-6, R-8 or duct sealing to 10% showed to be cost effective based on LSC.
   b. Adding attic insulation was cost effective based on LSC.
   c. Wall insulation showed to be cost effective On-Bill and on LSC for pre1978 and 1978-1991 vintages.
   d. Adding R-19 or R-30 floor insulation was cost-effective On-Bill and on LSC for pre1978 vintage. Adding R-19 floor insulation was cost-effective On-Bill and on LSC for 1978-1991 vintage.
   e. Upgrading to a cool roof at roof replacement with 0.2 or 0.25 solar reflectance was shown to not be cost effective. This is expected in Climate Zone 16 where heating loads dominate since cool roofs increase heating energy use by reducing solar heat gain through the roof and attic.
   f. Replacing old single pane windows with new high-performance windows has a very high cost and is typically not done for energy savings alone. However, energy savings showed to be substantial, even though it is not cost-effective.

4. The contractor surveys revealed overall higher heat pump costs than what has been found in previous analyses. This could be due to incentive availability raising demand for heat pumps and thereby increasing the price. This price increase may be temporary and may come down once the market stabilizes.
5. Table 45 shows how escalation rate assumptions will impact cost-effectiveness.
   a. If gas tariffs are assumed to increase substantially over time, in-line with the escalation assumption from the 2025 LSC development, cost-effectiveness substantially improves for the heat pump measures as well as envelope and duct measures over the 30-year analysis period and many cases become cost-effective that were not found to be cost-effective under the CPUC / 2022 TDV escalation scenario. There is much uncertainty surrounding future tariff structures as well as escalation values. While it's clear that gas rates will increase, how much and how quickly is not known. Future electricity tariff structures are expected to evolve over time, and the CPUC has an active proceeding to adopt an income-graduated fixed charge that benefits low-income customers and supports electrification measures for all customers.[2] The CPUC will decide in mid-2024 and the new rates are expected to be in place later that year or in 2025. While the anticipated impact of this rate change is lower volumetric electricity rates, the rate design is not finalized. While lower volumetric electricity rates provide many benefits, it also will make building efficiency measures harder to justify as cost-effective due to lower utility bill cost savings.
6. PV Measure: All PV measures were found to be cost-effective based On-Bill but not cost-effective based on LSC for both the Liberty and TDPUD permanent and nonpermanent rates for all three vintages.
   a. Combining a heat pump with PV allows the additional electricity required by the heat pump to be offset by the PV system while also increasing on-site utilization of PV generation rather than exporting the electricity back to the grid at a low rate.

[2] https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking

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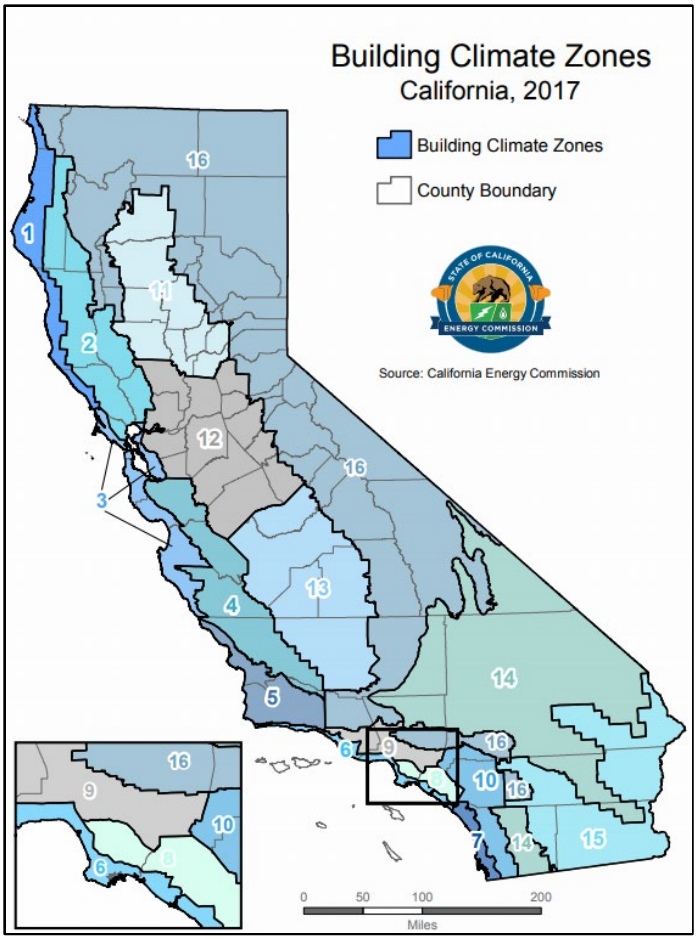
7 Appendices

7.1 Map of California Climate Zones

Climate zone geographical boundaries are depicted in Figure 1. The map in Figure 1 along with a zip-code search directory is available at: https://ww2.energy.ca.gov/maps/renewable/building_climate_zones.html

Figure 1. Map of California climate zones.



7.2 Utility Rate Schedules

The Reach Codes Team used 3CE electricity and SoCalGas gas tariffs detailed below to determine the On-Bill savings for each package.

7.2.1 Truckee Donner Public Utility District

Following are the TDPUD electricity tariffs applied in this study both for permanent residents (P10) and non-permanent residents (S10). The 2023 rates were used.[3] A net energy metering arrangement was evaluated that credits any net generation monthly based on the appropriate rate per the tariff.[4]

Residential customers are charged based on actual electric use recorded on an electric meter.

	2023	2024
Permanent Residents		
Customer Charge (per month)	$24.53	$27.47
Energy Charge (per kwh)	$0.1486	$0.1664
Non-Permanent Residents		
Customer Charge (per month)	$24.53	$27.47
Energy Charge (per kwh)	$0.1690	$0.1893

7.2.2 Liberty Utilities

Following are details on the Liberty Utility electricity tariff, D-1[5] , applied in this study. Baseline quantities were only applied to the permanent resident rates. A net energy metering arrangement was evaluated that credits any net generation monthly based on the appropriate rate per the tariff. Any generation credits do not offset the monthly minimum charge.[6] The Public Utilities Commission Reimbursement Surcharge of $0.001/kWh is applied monthly only when net kWh is positive. An annual Climate Credit of $131.01 was applied to each dwelling unit.[7]

[3] https://www.tdpud.org/customer-service/billing-options/rates
[4] https://www.tdpud.org/home/showpublisheddocument/200/636225809920030000
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SCHEDULE NO. D-1

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DOMESTIC SERVICE

APPLICABILITY

This rate schedule is applicable to all domestic power service to separately metered single family dwellings and individual living units of multi-unit complexes, where such units are metered by the Utility. Where electricity is furnished for EV charging, a customer may use the Electric Vehicle Supply Equipment (EVSE) as a submeter to measure EV charge load, and ancillary EV charge service (i.e., demand response, vehicle-grid integration, etc.). All EVSE used for submetering purposes must meet the requirements established in the Plug-in Electric Vehicle Submetering Protocol pursuant to Decision 22-08-024.

TERRITORY

Entire California Service Area.

RATES

Customer Charge
Per meter, per month $13.40

Energy Charges (Per kWh)

Residential Permanent Customers (see definition in Rule 1)

A. For Quantities up to and Including Baseline Quantities (See Special Condition 2):

Distribution		Generation 1		Vegetation 2	Greenhouse Gas (GHG)		SIP 4	PPP 5	GRCMA 6	BRRBA 7	Total	
$0.13577	(I)	$0.09433	(I)	$0.00000	$0.01517	(I)	$0.00072	$0.00364	$0.04700	$0.00409	$0.30072	(I)

B. For Quantities in Excess of Baseline Quantities (See Special Condition 2):

$0.16040	(I)	$0.11052	(I)	$0.00000	$0.01517	(I)	$0.00072	$0.00364	$0.04700	$0.00409	$0.34154	(I)

Residential Non-Permanent Customers (see definition in Rule 1)

$0.15401	(I)	$0.10095	(I)	$0.00000	$0.01517	(I)	$0.00072	$0.00319	$0.04700	$0.00409	$0.32513	(I)

Other Energy Charges (Per kWh)
Surcharges[8] $0.00100

Late Charge
1% on any amount 45 days in arrears from previous billings.

Minimum Charge
The per meter, per month Customer Charge.

1. Generation – Charge includes the Energy Cost Adjustment Clause Billing Factor as described in the Preliminary Statement, Number 6.
2. Vegetation – Charge to recover amounts in the Vegetation Management Balancing Account, as described in the Preliminary Statement, Number 18.
3. CEMA – Charge to recover amounts in the Catastrophic Event Memorandum Account as approved in D.16-12-024 and as described in the Preliminary Statement, Number 13.A.
4. SIP – Charge to recover the costs of the Solar Initiative Program as described in the Preliminary Statement, Number 21.
5. PPP – Charge to recover Public Purpose Programs funding energy efficiency and low-income assistance programs described in Preliminary Statement, Numbers 10, 17 and 19.
6. GRCMA – Charge to recover amounts in the General Rate Case Memorandum Account as described in the Preliminary Statement, Number 13.I.
7. BRRBA – Charge to recover amounts in the Base Revenue Requirement Balancing Account as described in the Preliminary Statement Number 8.
8. Surcharges – Charge to recover the Public Utilities Commission Reimbursement Surcharge as described in Rate Schedule RF and the Energy Commission Surcharge that is established by the California Energy Commission.

(Continued)

Issued by
Advice Letter No. 233-E Edward N. Jackson (Name) Date Filed: February 27, 2024
Decision No. D.24-02-021 President (Title) Effective Date: March 1, 2024
Resolution No.

7.2.3 Southwest Gas

The Southwest Gas monthly gas rates in $/therm applied in this analysis are shown in Table 27.[8] The monthly basic service charge was based on the most current tariff statements. For GN-10 daily baseline quantities were applied for Truckee.[9] A Franchise Fee of 2.5% was applied to the total monthly bill. Lastly, the annual California Climate Credit of $75.19 for 2024 was applied per dwelling unit for the GN-10 and GN-15 rates.[10]

The gas rates were developed based on the latest available gas rate for June 2024 and a curve to reflect how natural gas prices fluctuate with seasonal supply and demand. The seasonal curve was estimated from Southwest Gas monthly residential tariffs between 2014 and 2023. 12-month curves were created from monthly gas rates for each of the 10 years. The 10 annual curves were then averaged to arrive at an average normalized annual curve. The average normalized annual curve was developed based on residential rates for the South Lake Tahoe service area. Rate trends across multiple Southwest Gas tariffs were reviewed and were found to be consistent. The costs presented in Table 48 were then derived by establishing the June 2024 rate from the latest 2024 tariff as a reference point, and then using the normalized curve to estimate the cost for the remaining months relative to the June rates.

Table 48: Southwest Gas In-Unit Monthly Gas Rate ($/therm)

Month	GN-10		GN-15
	Baseline	Excess	All
Jan	$1.50286	$1.63472	$1.74296
Feb	$1.48598	$1.61636	$1.72339
Mar	$1.44151	$1.56799	$1.67182
Apr	$1.37614	$1.49688	$1.59600
May	$1.40796	$1.53149	$1.63290
June	$1.42727	$1.55250	$1.65530
July	$1.43645	$1.56248	$1.66594
Aug	$1.42996	$1.55542	$1.65842
Sept	$1.45005	$1.57728	$1.68172
Oct	$1.45044	$1.57771	$1.68218
Nov	$1.51394	$1.64677	$1.75581
Dec	$1.56500	$1.70231	$1.81503

[8] https://www.swgas.com/en/california-rates-and-regulation
[9] https://www.swgas.com/7200000202051/GS-10_GN-10_SLT-10---GRC_Eff-April-1-2021.pdf
[10] https://www.cpuc.ca.gov/climatecredit/

7.2.4 Fuel Escalation Rates

The average annual escalation rates in Table 44 were used in this study. The electricity and natural gas rates are based on assumptions from the CPUC 2021 En Banc hearings on utility costs through 2030 (California Public Utilities Commission, 2021a). Escalation rates through the remainder of the 30-year evaluation period are based on the escalation rate assumptions within the 2022 TDV factors. No data was available to estimate electricity escalation rates for the utilities that serve Truckee, therefore electricity escalation rates for PG&E and statewide natural gas escalation rates were applied.

Table 49: Real Utility Rate Escalation Rate Assumptions, CPUC En Banc and 2022 TDV Basis

Year	Statewide Natural Gas Average Rate (%/year, real)	PG&E Electric Average Rate (%/year, real)
2024	4.6%	1.8%
2025	4.6%	1.8%
2026	4.6%	1.8%
2027	4.6%	1.8%
2028	4.6%	1.8%
2029	4.6%	1.8%
2030	4.6%	1.8%
2031	2.0%	0.6%
2032	2.4%	0.6%
2033	2.1%	0.6%
2034	1.9%	0.6%
2035	1.9%	0.6%
2036	1.8%	0.6%
2037	1.7%	0.6%
2038	1.6%	0.6%
2039	2.1%	0.6%
2040	1.6%	0.6%
2041	2.2%	0.6%
2042	2.2%	0.6%
2043	2.3%	0.6%
2044	2.4%	0.6%
2045	2.5%	0.6%
2046	1.5%	0.6%
2047	1.3%	0.6%
2048	1.6%	0.6%
2049	1.3%	0.6%
2050	1.5%	0.6%
2051	1.8%	0.6%
2052	1.8%	0.6%
2053	1.8%	0.6%

Get In Touch

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