Impact Evaluation of 2021–2022 New Buildings Program

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ACRONYMS AND ABBREVIATIONS

Acronyms/abbreviation	Definition
AHRI	American Heating and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BMS	Building management system
CEE	Consortium for Energy Efficiency
cfm	Cubic feet per minute
DHP	Ductless heat pump
DHW	Domestic hot water
DOE	Department of Energy
DUP	District utility plant
EM&V	Evaluation, measurement, and verification
EMS	Energy management system
Energy Trust	Energy Trust of Oregon
eQUEST	The Quick Energy Simulation Tool
ERV	Energy recovery ventilator
EUI	Energy use intensity
gph	Gallons per hour
IECC	International Energy Conservation Code
IESVE	Integrated Environmental Solutions Virtual Environment
ITE	Information technology equipment
kBtu	Thousands of British thermal units
kW	Thousands of watts
kWh	Thousands of watt-hours
LPD	Lighting power density
MAD	Measure approval document
OCEC	Oregon Commercial Energy Code
OEESC	Oregon Energy Efficiency Specialty Code
OZERCC	Oregon Zero Energy Ready Commercial Code
PAC	Pacific Power
PGE	Portland General Electric
PMC	Program Management Contractor
PNNL	Pacific Northwest National Laboratory
PPS	Probability proportional to size
PTNZ	Path to Net Zero

Acronyms/abbreviation	Definition
QA/QC	Quality assurance and quality control
RR	Realization rate
SHGC	Solar heat gain coefficient
SRAF	Savings realization adjustment factors
TRC	Total resource cost
UMLH	Unmet load hours
VRF	Variable refrigerant flow

1.0 EXECUTIVE SUMMARY

The Tetra Tech team (Tetra Tech and Rouj Energy) presents the following evaluation, measurement, and verification (EM&V) report for the Energy Trust of Oregon (Energy Trust) 2021−2022 New Buildings program.

1.1 PROGRAM DESCRIPTION

Energy Trust New Buildings has a long-term goal to transform Oregon's commercial new construction market to deliver low-energy-use buildings statewide. The program employs a range of tactics and strategies to advance the market from today's current practices. New Buildings was established as a market transformation program in 2010, near the time of the state's first significant code change, which took effect several years after this program was established by Energy Trust and revealed the pitfalls with changes to building codes. The program has a very code-focused market and has established that the program baseline is the Oregon Energy-Efficiency Specialty Code (OSEEC). The program has two ways of claiming savings relative to code: compliance with code and project improvements beyond code. To make market progress and efficiency gains, the program focuses on the design of buildings and systems, as described further below, and influences the market beyond just the smaller savings potential brought through gains from products. Given the complexities and challenges of transforming the new construction market in ways that deliver cost-effective energy efficiency, the program utilizes multiple strategies simultaneously as part of the overall program's framework to scale high-performance building design into the market.

As a resource acquisition and market transformation program, the New Buildings (and New Multifamily) program provides financial incentives and technical assistance to owners who install energy efficiency measures better than the Oregon energy code[1] in new commercial construction and major renovation projects and supports the market through market transformation initiatives such as training and education, and compliance with codes. The program aims to save electricity and natural gas throughout the Oregon service areas of its funding utilities[2] as a part of Energy Trust's broader mission: to change how Oregonians produce and use energy by investing in efficient technologies and renewable resources that save dollars and protect the environment.

New Buildings references code baseline to determine savings and, within a program year, may be working with projects under codes or standards before new or emerging codes and standards. When codes and standards change, the program adjusts to the new baseline(s), holding newly enrolled projects to a new, higher standard while continuing to wind-up projects that fall under previous codes and standards. Managing several codes and standards changes occurring in the Oregon market (and with some national or industry baseline changes) has required New Buildings staff to develop a market transformation savings model and strategy to help guide this multi-faceted program. This context is important for several reasons: claiming appropriate levels of savings from participating projects; calculating market transformation savings (driven by project square footage) in New Buildings beyond the Northwest Energy Efficiency Alliance's (NEEA) model; and confirming separate, additional market transformation savings claimed through NEEA due to advanced codes.

New Buildings often handles multiple drivers to program baselines in addition to codes, such as avoided cost updates, market changes, and emerging technologies. The New Buildings program offers five tracks for incentives on new construction projects:

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[1] Energy codes included in the 2021−2022 New Buildings program include the 2014 Oregon Energy Efficiency Specialty Code, the 2019 Oregon Commercial Energy Code, and the 2021 Oregon Energy Efficiency Specialty Code.

[2] Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas, and Avista.

- **System-Based.** System-Based offers a combination of prescriptive and custom-calculated measures for individual systems within a building.
- **Market Solutions.** Market Solutions offerings encourage projects to push the envelope of energy efficiency by offering higher incentives for the installation of efficiency measure packages to achieve above-code levels of performance. The Multifamily Market Solutions workbook tool allows project owners to estimate the potential energy savings, usually on a per-square-foot basis, and incentives for improving the overall efficiency of the building design for both new construction and major renovation projects. The offering covers building energy uses, including envelope, HVAC, domestic hot water (DHW), lighting, and appliances.
- **Data Center.** The Data Center track offers support for the specific needs in the construction of new data centers. The program offers incentives for improved energy efficiency of HVAC measures and power distribution systems. Computer rooms (or series of computer rooms that share data center systems) serving a total information technology equipment (ITE) load greater than 10 kW and 20 W/ft^2 are eligible for this track.
- **Whole Building.** The Whole Building path provides a performance pathway in alignment with the 2019 Oregon Zero Energy Ready Commercial Code (OZERCC) and 2021 Oregon Energy Efficiency Specialty Code (OEESC). Whole Building provides a multi-incentive application process for whole-building energy modeling, early design assistance, technical design assistance, installed energy-efficient design features, and energy metering.
- **Path to Net Zero (PTNZ).** PTNZ is an extension of the Whole Building track. In addition to the multi-incentive process, PTNZ provides incentives for achieving PTNZ status by meeting energy use intensity (EUI) goals that meet or exceed Architecture 2030 Challenge guidelines.

1.2 EVALUATION RESULTS

The Tetra Tech team found the program achieved over 46 million kWh and 591 thousand therms in savings in the 2021−2022 program years across 669 sites. Table 1 shows the evaluated savings results for both fuels by program year and program track, the realization rates (RR), and relative precision at a 90 percent confidence interval.

Table 1. Annual Evaluated Savings and Realization Rates by Program Year and Track

Track	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
2021									
Data Center	2	3,341,651	2,619,169	78%	0%	0	0	N/A	N/A
Market Solutions	57	7,654,012	6,627,130	87%	8%	137,415	129,642	94%	12%
Path To Net Zero	8	3,516,184	3,546,234	101%	2%	50,474	41,755	83%	7%
System Based	281	13,905,592	13,144,606	95%	6%	126,069	119,201	95%	5%
Whole Building	9	2,013,145	2,027,760	101%	24%	37,149	30,228	81%	8%
2021 total	**357**	**30,430,584**	**27,964,899**	**92%**	**4%**	**351,107**	**320,827**	**91%**	**5%**

Track	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
2022									
Data Center	2	14,540	14,591	100%	0%	0	0	N/A	N/A
Market Solutions	52	8,249,664	6,674,617	81%	16%	64,696	69,455	107%	8%
Path To Net Zero	7	1,223,303	1,236,328	101%	0%	26,141	21,912	84%	N/A
System Based	241	8,173,060	7,355,218	90%	7%	143,197	104,347	73%	17%
Whole Building	10	3,277,199	3,317,311	101%	0%	83,869	74,735	89%	15%
2022 total	**312**	**20,937,766**	**18,598,065**	**89%**	**7%**	**317,904**	**270,449**	**85%**	**11%**
Grand total	**669**	**51,368,350**	**46,562,964**	**91%**	**4%**	**669,010**	**591,276**	**88%**	**6%**

One of the key objectives for the evaluation was to estimate the annual energy savings with a better-than-ten-percent precision at the 90 percent confidence interval. The Tetra Tech team was able to achieve this for the electric savings in both years, as well as the natural gas savings in 2021. The natural gas savings in 2022 came in slightly higher (10.9 percent) than the evaluation's target.

The Tetra Tech team sampled across three additional strata for the impact analysis: building sampling type (with small building types aggregated into a *miscellaneous* category), program track, and applicable building code. These strata were sampled for 20 percent precision at the 90 percent confidence interval.

Realization rates were affected most by a lack of negative savings claims on individual measure breakouts for Whole Building and PTNZ tracks, two projects that were no longer operating due to events outside of the program's control, and variances in Market Solutions *multifamily* projects for the 2019 and 2021 code years, which used ModelKit for their savings analysis.

Table 2 shows the results of the evaluation by building type. Most building types achieved the 20 percent target. *Food service* had a precision of 46 percent on kilowatt-hours and 38 percent on therms due to a project that experienced a force majeure closure during the first year of operation. *Lodging* achieved a 32 percent relative precision due to a project that had not completed construction at the time of the evaluation.

Most realization rates were between 80 and 97 percent across the building types. The largest realization rate deviations from 100 percent were 78 percent for *data center* kilowatt-hour savings and 71 percent for *parking/transportation* therms.

Table 2. Annual Evaluated Savings and Realization Rates by Building Type

Building type	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
College/ university	20	3,904,371	3,633,612	93%	4%	23,882	19,294	81%	6%
Data center	4	3,356,191	2,633,760	78%	0%	0	0	N/A	N/A

Building type	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
Food service	50	242,729	220,763	91%	46%	40,257	33,858	84%	38%
Hospital/ healthcare	33	2,244,831	2,158,538	96%	14%	32,658	25,711	79%	8%
K−12 school/ education	86	5,500,274	5,456,767	99%	4%	179,152	154,648	86%	19%
Lodging	35	2,381,835	2,016,578	85%	13%	50,809	46,203	91%	32%
Miscellaneous	202	8,029,376	7,556,018	94%	8%	73,485	60,495	82%	6%
Multifamily	139	17,856,034	15,392,701	86%	7%	214,281	206,341	96%	10%
Office	90	4,870,399	4,731,031	97%	3%	48,899	40,760	83%	6%
Parking/ transportation	10	2,982,309	2,763,197	93%	3%	5,589	3,966	71%	2%
Total	**669**	**51,368,350**	**46,562,964**	**91%**	**4%**	**669,010**	**591,276**	**88%**	**6%**

Table 3 shows the evaluation results by program track. All of the tracks achieved a lower-than-ten-percent relative precision for kilowatt-hour savings. The System Based and Whole Building tracks achieved 10 percent and 11 percent therms savings relative precisions.

Most tracks had realization rates between 84 and 101 percent. The largest realization rate deviation from 100 percent was 78 percent for the Data Center track.

Table 3. Annual Evaluated Savings and Realization Rates by Program Track

Track	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
Data Center	4	3,356,191	2,633,760	78%	0%	0	0	N/A	N/A
Market Solutions	109	15,903,675	13,301,747	84%	9%	202,111	199,097	99%	8%
Path To Net Zero	15	4,739,486	4,782,562	101%	2%	76,616	63,667	83%	8%
System-Based	522	22,078,652	20,499,825	93%	5%	269,265	223,548	83%	10%
Whole Building	19	5,290,345	5,345,071	101%	4%	121,018	104,963	87%	13%
Total	**669**	**51,368,350**	**46,562,964**	**91%**	**4%**	**669,010**	**591,276**	**88%**	**6%**

Table 4 shows the evaluation results by building code. All of the tracks achieved a lower-than-20-percent relative precision for kilowatt-hour and therms savings. The realization rates ranged from 74 to 94 percent. The 74 percent realization rate for the 2021 code for therms savings was due to adjustments from ModelKit savings for Market Solutions projects and unclaimed negative savings for Whole Building and PTNZ tracks.

Table 4. Annual Evaluated Savings and Realization Rates by Building Code

Code	Sites	Electricity savings				Natural gas savings			
		Reported (kWh)	Evaluated (kWh)	RR	Relative precision	Reported (therms)	Evaluated (therms)	RR	Relative precision
2014 code	228	32,281,622	30,097,788	93%	4%	407,669	367,455	90%	5%
2019 code	384	18,428,406	15,894,024	86%	8%	245,932	212,432	86%	14%
2021 code	57	658,322	571,153	87%	14%	15,409	11,389	74%	4%
Total	**669**	**51,368,350**	**46,562,964**	**91%**	**4%**	**669,010**	**591,276**	**88%**	**6%**

Table 5 presents the results of the demand savings analysis by building type, program year, peak period, and utility (Pacific Power (PAC) and Portland General Electric (PGE)). The Tetra Tech team reviewed the load shapes specified for each of the electric savings measures in the sampled projects and made adjustments where a better matching load shape was present. There were 726 electric savings measures, and 143 were adjusted. Most of the adjustments (104) were from a *flat – ele* load shape to another load shape, such as *lighting*, *cooling*, *heating*, or *ventilation*. There were also 23 measures that had a *none – ele* load shape specified that were adjusted to a load shape that would give some credit for savings, such as *hot water* and *refrigeration*.

Table 5. Annual Demand Savings Results by Building Type

Building type	2021				2022			
	PAC summer (MW)	PAC winter (MW)	PGE summer (MW)	PGE winter (MW)	PAC summer (MW)	PAC winter (MW)	PGE summer (MW)	PGE winter (MW)
College/university	145	291	147	338	319	314	316	308
Data center	330	325	331	324	2	2	2	2
Food service	18	20	17	22	14	15	13	14
Hospital/healthcare	130	123	126	126	197	206	194	200
K-12 school/education	663	655	654	656	182	188	179	180
Lodging	153	142	147	147	192	328	207	357
Miscellaneous	724	718	689	745	391	408	380	394
Multifamily	1,024	1,683	1,079	1,591	1,178	1,901	1,237	2,106
Office	514	536	510	553	208	233	204	234
Parking/transportation	429	375	406	392	6	5	5	5
Total	**4,130**	**4,870**	**4,107**	**4,894**	**2,687**	**3,601**	**2,738**	**3,800**

1.3 FINDINGS AND RECOMMENDATIONS

Overall, the Tetra Tech team found the New Buildings program operating in a manner consistent with industry standards and achieving significant savings. In particular, the modeling results for proposed buildings for the Whole Building and PTNZ tracks were well matched to the utility billing data. In addition, very few parameter adjustments for the Whole Building and PTNZ tracks were necessary from as-built drawing reviews, control system data, and site visits.

The Tetra Tech team has the following high-level findings and recommendations from the evaluation:

Adopt a strict file system protocol for Whole Building and PTNZ project energy models. The implementer documents the names of the simulations used at each step of the modeling process; however, the results for several projects differed from the final project savings in a few cases. For other projects, the simulation models from different iterations were intermixed. Finally, the source of the individual measure runs was not stored or documented consistently between projects. The Tetra Tech team recommends adopting a file structure that matches each of the submittals documented in the Model Summary workbooks.

Claim negative savings for all measures on Whole Building and PTNZ projects. The Tetra Tech team found 12 instances of measures under the Whole Building and PTNZ tracks that had negative savings calculated from their individual measure runs, but the savings were not included in the tracked data. The program manual states that these should not be tracked but should be entered into program attribute data; Energy Trust has confirmed that this was not the intent of the guidance that had been discussed. Since savings for these two tracks are calculated at the whole-building level and separated into major measures, excluding any negative kilowatt-hour or therms values overstates project savings. The Tetra Tech team found 96,290 kWh and 23,600 therms among the sampled projects that were overstated from following this policy. The Tetra Tech team recommends updating the program manual to distinguish between the whole-building and measure-specific treatment of negative results.

Review the Market Solutions findings and recommendations on projects using ModelKit. For code years 2019 and 2021, Market Solutions used ModelKit (a front end for producing EnergyPlus simulation files) for multifamily projects to estimate savings for a suite of measures. ModelKit is based on Department of Energy (DOE) prototype models and applies ratios of the information entered to generate simulation files. The Tetra Tech team examined these simulation files and found significant deviations in results due to area-per-apartment unit scaling and pass-through of savings for measures that were not selected as part of the project. The Tetra Tech team recommends that Energy Trust and implementation teams review the detailed findings in Appendix E and determine which measures should remain calculated as part of the ModelKit measure mix and which measures should be moved outside of the models.

Consider providing small incentives for customers enabling trending on Energy Management Systems (EMS). The Tetra Tech team found that most projects had an EMS installed, but for most sites, trending of energy use beyond a high level was not enabled. EMS data provides a cost-effective way to evaluate the performance of the building. For most projects where the Tetra Tech team was hoping to use EMS data to look at building performance over time on key systems, we found the trending was not enabled. Offering a small incentive to enable trending could increase evaluation savings estimates and build operational feedback in future evaluation efforts.

Explore options to increase facility operator participation in future evaluations. The Tetra Tech team faced significant difficulties in obtaining participation in the evaluation. Some of the barriers faced include buildings changing ownership, project contacts (both individuals and firms) no longer having a vested interest in the project, and operators unwilling to give time and effort. Some potential options include incentives for buildings that participate in the evaluation or clearly defined expectations for participation after the project closes.

Memo

To: Energy Trust Board of Directors

From: Shelly Carlton, Sr. Program Manager – New Buildings Program
Sarah Castor, Evaluation & Engineering Manager

cc:

Date: April 3, 2025

Re: Staff Response to the 2021-2022 New Buildings Program Impact Evaluation

Energy Trust of Oregon undertook an impact evaluation of the 2021-2022 New Buildings program to assess the reliability of program energy savings estimates and identify opportunities to improve savings calculation methods. The evaluation reviewed all five tracks of the New Buildings program: Data Centers, Market Solutions, Path to Net Zero, System-Based and Whole Building. The last New Buildings program impact evaluation, covering the 2018 and 2019 program years, was published in 2021. Energy Trust decided to skip the impact evaluation of the 2020 program year, as program implementation in 2020 was consistent with previous years and savings realization rates had been stable for several years.

For the 2021-2022 impact evaluation, the evaluator reviewed 110 projects out of the 669 completed by the program, providing good precision of results by program year, fuel and for most program tracks, building code versions and building types. Overall, realized savings were good, coming in at 91% for electricity and 88% for natural gas.

The evaluation found the program did not do as well in estimating savings for Market Solutions multifamily projects permitted under the 2019 and 2021 codes as it had with projects permitted under the 2014 code, due to the changes in modeling protocols. The program plans to use a new modeling system for the Market Solutions offer, beginning in late 2025, and that tool will be aligned with the ASHRAE 2022-based 2025 Oregon Commercial Energy Code.

Since the last evaluation was completed in 2021, Energy Trust has adopted a practice of including negative interactive savings in all savings claims. Negative interactive savings occur when a measure saves one fuel, but also results in an increase in usage of the other fuel – for example, a measure that saves electricity but results in increased natural gas use. The evaluator noted the program had not accounted for the negative interactive savings for several measures in the Whole Building and Path to Net Zero tracks. In 2021 and 2022, negative interactive savings represented less than 0.01% of the reported electric savings for the Whole Building and Path to Net Zero tracks, but about 12% of the reported gas savings and the largest reduction to realized savings for those tracks.

Since the implementation of the 2019 Oregon Energy Efficiency Specialty Code, the program has updated the way it claims savings, and projects under the 2019 and later codes have their negative interactive savings included in reported savings. Because of the long development cycle for New Buildings projects, the 2023 impact evaluation, currently in progress, may still encounter projects that have not accounted for negative interactive savings, but they should no longer be present in projects completed after 2023.

As noted in previous impact evaluations for New Buildings and Energy Trust's other commercial and industrial programs, retaining and organizing project documentation is an area where Energy Trust can continue to improve. The New Buildings program is continuing work to increase Whole Building energy simulation documentation, making them more consistent and ensuring final modeling files are included in completed project files provided to Energy Trust. Program staff will describe the basis for the final savings claim and include properly labeled supporting documentation, including any post-processing calculations performed on the model outputs. In addition, the program will ensure all available as-built construction documents are in the completed project files, including mechanical drawings and equipment schedules.

The realization rate for the Data Center track in 2021 was lower than other tracks, at 78%, as a result of one large project. This project was part of a separate evaluation process and the evaluation found that the site's computer room air conditioners did not perform as well as expected. All three of the other data center projects in the 2021-2022 impact evaluation earned realization rates of 100%.

This evaluation was challenged by a lower rate of customer participation in evaluation than we have seen in previous years, a finding that mirrors recent impact evaluations for Energy Trust's other commercial and industrial programs. We were glad that the program and evaluator were able to work together to achieve good precision of results despite the challenges to customer recruitment. To boost cooperation with evaluation going forward, Energy Trust has begun offering incentives to New Buildings customers to participate in program impact evaluations. In early 2024, program and evaluation staff worked together to develop a fact sheet about evaluation that is now provided to all New Buildings customers when they complete a project, to encourage participation and set expectations about the experience.

2.0 BACKGROUND

2.1 PROGRAM DESCRIPTION

Energy Trust of Oregon's (Energy Trust) New Buildings program began in August 2003 and is implemented by a program management contractor (PMC) on behalf of Energy Trust. The current PMC is CLEAResult. New Buildings serves new commercial construction, major renovations, tenant improvements, and building additions, including multifamily buildings. New Buildings helps customers design and build energy-efficient buildings from early design to post-occupancy, utilizing a variety of services and incentives, including early design assistance, technical service incentives, technical review, and installation and commissioning incentives. In addition, the program provides regular industry training for developers and design and engineering firms, and it supports state efforts to update commercial energy codes.

Since new American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)-based codes were adopted in 2019 and 2021, the program has had to adapt its approach to Whole Building projects since the performance path of the new codes no longer provides a simple way to estimate project incremental costs given that there is no single way to minimally comply with code. As a result, the Whole Building program tracks have been operating under a cost-effectiveness exception to the total resource cost (TRC) test from the Oregon Public Utilities Commission since the TRC benefit-cost ratio can no longer be computed. However, the program has not yet processed a large volume of Whole Building projects that are subject to the new codes due to the long lead times for new construction projects.

During the 2021 and 2022 program years, 669 projects were completed at 669 distinct sites, with reported annual energy savings[3] of approximately 51 million kilowatt-hours and 669,000 therms, as shown in Table 6.

Table 6. Savings Reported and Projects Competed in 2021 and 2022

Year	Sites	Projects	Reported (kWh)	Reported (therms)
2021	357	357	30,430,584	351,107
2022	312	312	36,203,576	317,904
Total	**669**	**669**	**51,368,350**	**669,010**

New Buildings has several tracks that use different approaches to help customers select energy efficiency measures and quantify energy savings and incentive amounts:

- The **Data Center** track focuses specifically on data center opportunities.
- The **Market Solutions** track streamlines participation by presenting customers with *good*, *better*, *best*, and *very best* packages of measures specific to different building types. This track uses workbooks based on pre-modeled prototype buildings to calculate energy savings and incentives for multifamily buildings. Other building types were included in the past, but in the 2021 and 2022 program years, 97 percent of Market Solutions projects were *multifamily* buildings (the remaining 3 percent were *food service*).

[3] Reported savings shown in this report are Energy Trust's "working savings" and may differ from savings shown in Energy Trust's quarterly and annual reports, which apply adjustment factors based on previous impact evaluation results to approximate realized savings.

- The **System-Based** track uses a combination of individually selected prescriptive- and custom-calculated measures to quantify savings and incentives for individual systems within a building.
- The **Whole Building** track employs custom building simulation models to quantify whole-building and measure-level energy savings. This track is typically reserved for large or complex projects expected to achieve relatively high savings.
- **Path to Net Zero (PTNZ)** began as a pilot to push innovative designers and developers to try to achieve net zero energy use. These projects are now part of the Whole Building track but are unique because of their aggressive goals and use of on-site renewables.

There is some crossover of analysis methods between tracks, especially for standard equipment measures, which use prescriptive savings based on standard assumptions and calculations. This impact evaluation represents the first program years with projects completed under Oregon's new ASHRAE-based energy codes, which were adopted in 2019 and updated in 2021. To date, projects subject to the new codes have been concentrated in the System-Based track with relatively few projects subject to the new codes in the Whole Building tracks (Whole Building, PTNZ, and Market Solutions) to date. As part of the evaluation, nuances and issues in how savings were calculated that were subject to the new ASHRAE-based codes, especially in the Whole Building tracks, were explored.

The methodology of this evaluation was adapted to the ongoing effects of the COVID-19 pandemic, which included conducting site visits at sensitive sites (like hospitals) remotely when feasible, relying on the site contacts and PMC staff to provide more information, using EMS and utility data whenever possible, and accepting a lower level of savings certainty in some cases.

2.2 RESEARCH OBJECTIVES

Energy Trust performs process and impact evaluations of its major programs on a regular basis. Impact evaluations provide an important accountability role to ensure that the energy savings Energy Trust invests in and reports to its stakeholders are actually achieved. The evaluation results, specifically the savings realization rates, are incorporated into Energy Trust's savings realization adjustment factors (SRAF), which are applied to Energy Trust savings claims for each fuel prior to reporting them.

Energy Trust has a separate process for very large and complex commercial and industrial projects, including New Buildings projects. These projects are evaluated on an individual basis with their own evaluation plan due to their large savings, the complexity of the projects, and the need to evaluate them on a different schedule than allowed by the program-wide impact evaluation. Five large projects from 2021 and 2022 were selected for evaluation through this separate process, with two projects completed and their results included in this report.

The goals of the 2021−2022 impact evaluation were:

- Develop reliable estimates of New Buildings program gas and electric savings and realization rates for the 2021 and 2022 program years separately.
    - Additionally, provide gas and electric realization rates by program track, building type, and measure category.
    - Estimate the impact of the 2019 and 2021 ASHRAE-based Oregon energy codes on savings realization rates for Whole Building projects.

- Develop estimates of electricity utility system demand savings for the program overall for the 2021 and 2022 program years.
    - Provide electricity utility demand savings estimates by program track, building type, and measure category.
- Provide feedback on Whole Building modeled savings calculations under the 2019 and 2021 ASHRAE-based Oregon energy codes.
- Report important observations about New Buildings projects and make recommendations for specific changes that will help Energy Trust improve the accuracy of future ex-ante savings estimates, future engineering studies, and the results of future impact evaluations.

3.0 METHODOLOGY

This section summarizes the key research questions and the methods used to conduct the Energy Trust of Oregon (Energy Trust) New Buildings program evaluation. The Tetra Tech team completed the following activities to address the key research questions:

- review program materials and tracking data to support the development of the work plan and baselines for each customer segment within the program;
- develop samples for data collection activities;
- conduct an in-depth review of modeling procedures and methodologies focused on the 2019 and 2021 code adoptions;
- collect data and documentation for sampled projects;
- review the custom estimation procedures and methods;
- analyze project-level energy savings methods and assumptions;
- provide recommendations from the use of project-level documentation, measurement and verification (M&V), and appropriateness of baseline assumptions; and
- review the accuracy and consistency of tracked savings.

The data collection and analysis activities are further described below, including tables summarizing the sampling strategies for primary data collection efforts. The Tetra Tech team worked collaboratively with Energy Trust and program management contractor (PMC) staff to discuss any inconsistencies or challenges that were identified throughout the evaluation.

3.1 KEY RESEARCHABLE QUESTIONS

Based on discussions with Energy Trust and PMC staff—and the program tracking data review—the Tetra Tech team identified key researchable questions to be addressed through the evaluation. Table 7 documents these key researchable questions, along with the activities that will address the questions.

Table 7. Energy Trust New Buildings Program Researchable Questions

Researchable questions	Activity to support the question
How well are the 2019 and 2021 code changes reflected in energy modeling? Are there any concerns requiring modeling protocol adjustments?	• Whole-building project savings review
What assumptions were used to develop savings estimates? Are the savings reasonable, following good industry practice, and in compliance with stated baseline policies? Are there any updates that should be made?	• Program tracking data review • Engineering desk reviews
What are the program's verified gross kilowatt-hour and natural gas savings for the 2021 and 2022 program years? Are there issues with building code, building type, or program track stratifications that require updates?	• Program database review • Engineering desk reviews • Facility personnel interviews • Virtual or in-person site visits • Measurement of key variables

3.2 IMPACT EVALUATION ACTIVITIES

This section discusses the impact activities that were conducted for the New Buildings program. From these activities, the Tetra Tech team calculated gross savings values for each sampled point and developed realization rates (the ratio between evaluated and reported savings). These realization rates were then applied to the entire participant population in order to reflect the program's evaluated savings estimates.

The impact evaluation activities included the following:

- **Kick-off meeting and work planning.** On April 4, 2023, the Tetra Tech team conducted a kick-off meeting with Energy Trust and PMC staff to review the proposed evaluation approach and obtain feedback. Tetra Tech then developed a work plan that reflected discussions during the meeting.
- **Program tracking data and materials review.** The Tetra Tech team reviewed the program's tracking data, tracked savings, and related documentation. The team compared all documentation and verified consistency.
- **Whole-building project savings review.** The Tetra Tech team conducted an in-depth review of three Whole Building projects using the 2019 or 2021 energy codes. The review focused on modeling procedures for code adherence resulting from the 2019 energy code adoption and the subsequent 2021 energy code update. The results of this review are described in the memo in Appendix A, which was delivered to Energy Trust and PMC staff.
- **Engineering desk reviews.** For all projects in the sample, the Tetra Tech team reviewed the custom savings methodologies and assessed the reasonableness of the electric and natural gas savings for the New Buildings program by comparing the modeling methodologies used among projects to industry best practices. The Tetra Tech team also reviewed and compared project-level energy savings methods and assumptions to assess and provide recommendations related to the use of project-level documentation, M&V, and the use of code- and market-based baseline assumptions.
- **Site-specific M&V plans.** For all projects, the Tetra Tech team drafted site-specific M&V plans, which outlined the measures incented by the project and the key parameters for evaluation. These parameters were collected through facility operator interviews, site visits, or measurement of key parameters, as necessary.
- **Facility operator interviews.** For all projects within the sample, the Tetra Tech team attempted to schedule facility operator interviews to discuss the project and current building operations and assess parameters used in the energy analysis. The results of the facility operator interviews included *requests for a site visit* (virtual or in-person) or *additional documents* (such as as-built drawings, commissioning reports, and submittals).
- **Site visits.** For most projects that completed interviews, the Tetra Tech team attempted to conduct virtual or in-person site visits to verify equipment installations and operational parameters. The decision to conduct virtual or in-person site visits was based on the complexity of the verification, the cost of conducting in-person verification, or customer preference.
- **Measurement of key parameters.** For a subset of site visits, the Tetra Tech team conducted measurement of key parameters, which included the installation of short-term dataloggers, collection of building management system (BMS) data, or coordination with facility operators for other parameters. The desired parameters were outlined in the site-specific M&V plans and communicated/coordinated during or after the facility operator interview.

- **Energy use intensity (EUI) analysis.** For all projects in the sample, the Tetra Tech team identified characteristics from engineering desk reviews and included requests for billing data as part of the facility operator interviews. The EUI analysis provides a normalized comparison between building size, building type, and estimated annual energy use. The utility data were examined for outliers and reasonableness given the project scope. The results of the individual site EUIs were compared to ENERGY STAR® median EUI values, and an overall area-weighted result was calculated.
- **Reporting.** The Tetra Tech team made project savings calculations, site-specific M&V reports, facility operator interview transcripts, and other documentation for all projects in the sample available for PMC staff and Energy Trust review for project-level results. Where feedback was warranted, the Tetra Tech team revised savings estimates for individual projects prior to the drafting of this report.

3.3 LEVEL OF VERIFICATION ACTIVITIES, SITE VISIT, AND KEY MEASUREMENT SELECTION

As part of the site-specific M&V plan preparation, the Tetra Tech team grouped measures by key measurements (such as similar annual operating hours for *lighting*) and applied variance criteria. From this activity, measures were sorted into *high*, medium, and *low* thresholds for potential variances in overall project savings. Measures in the *high* variance group were more likely to receive in-person site visits and direct metering of key parameters; measures in the *low* grouping were more likely to receive verification-only activities. As part of this process, the overall project savings within the projects sampled for the strata by building type, project year, and code cycle were considered.

Similarly, the results of facility operator interviews led to a reassessment of the energy savings measures for individual projects. After conducting the interview, there were measures with higher variance potential than expected where an in-person site visit or direct metering was conducted to reduce evaluated savings risk.

Direct measurement included installation of metering equipment, collection of energy management system (EMS) or BMS data, and spot measurements of key parameters. The existence of EMS/BMS systems was explored as part of the facility operator interviews to determine whether key data could be collected through customer systems remotely or whether in-person site visits would be necessary. Finally, direct metering was only necessary when EMS/BMS data were insufficient and the potential for variation was high for individual measures.

3.4 DATA COLLECTION ACTIVITIES

Table 8 summarizes the achieved activities for each of the evaluation activity levels.

Table 8. Impact Analysis Activities

Data collection activity	Number of completed projects
Engineering desk reviews	110
Facility operator interviews	71
Site Visits (in-person)	22
Site visits (virtual)	28
Measurement of key parameters	12

3.5 SAMPLING PLAN

The Tetra Tech team developed the sampling plan based on program tracking data and discussions with Energy Trust. The stratified sampling plan targeted 15 percent relative precision at a 90 percent confidence level (90/15) at the track-, building-, and energy-code-cycle levels. The tables presented in this section include sample allocations to meet the 90/15 target for each breakout.

The sampling occurred in four stratifications based on the sample sizes. Probability proportional to size (PPS) sampling for both gas and electric savings was used to select projects at each stage of the sampling process.

3.5.1 Building Type Classification

In order to sample based on the building type, classifications from the granular tracking data were necessary. The Tetra Tech team reviewed the tracking data categories for *market name* and *market type*[4] to classify the buildings. First, the Tetra Tech team classified the data into general building type categories and then examined the proportions of the kilowatt-hour and therms savings to the total population. Categories that did not represent at least three percent of kilowatt-hour or therms savings were combined into the *miscellaneous* building type. Table 9 shows building type classifications.

Table 9. Building Type Classifications

Market name	Market type[5]	Building type	Sampling type
Affordable multifamily	Multifamily	Multifamily	Multifamily
Arts, entertainment, and recreation	Arts, entertainment, and recreation	Public assembly	Miscellaneous
Assisted living	Multifamily	Lodging	Lodging
Bank/financial institution	Bank/financial institution	Office	Office
Beverage production	General manufacturing	Manufacturing/food processing	Miscellaneous
Car dealership/showroom	Car dealership/ showroom	Service	Miscellaneous
Chemical manufacturing	General manufacturing	Manufacturing/food processing	Miscellaneous
College/university	College/university	College/university	College/university
Commercial		Other	Miscellaneous
Convenience store	Convenience store	Food sales	Miscellaneous
Courthouse/probation office	Courthouse/probation office	Public safety	Miscellaneous
Data center	Data center	Data center	Data Center
Fabricated metal product manufacturing	General manufacturing	Manufacturing/food processing	Miscellaneous
Fire station	Fire station	Public safety	Miscellaneous
Fleet yard	Fleet yard	Parking/transportation	Parking/transportation

[4] *et_marketname* and *markettype* fields, respectively, in Energy Trust's tracking data.
[5] The *markettype* field for projects with a *commercial* or *industrial et_marketname* is blank in the tracking data.

Market name	Market type[5]	Building type	Sampling type
Food processing	General manufacturing	Manufacturing/food processing	Miscellaneous
Food service	Food service	Food service	Food service
General manufacturing	General manufacturing	Manufacturing/food processing	Miscellaneous
Grocery	Grocery	Food sales	Miscellaneous
Gym/athletic club	Gym/athletic club	Public assembly	Miscellaneous
Healthcare	Healthcare	Hospital/healthcare	Hospital/healthcare
High school	K−12 school	K−12 school/ education	K−12 school/ education
Hospital	Hospital	Hospital/healthcare	Hospital/healthcare
Industrial		Other	Miscellaneous
Jail/reformatory/ penitentiary	Jail/reformatory/ penitentiary	Public safety	Miscellaneous
K−12 school	K−12 school	K−12 school/ education	K−12 school/ education
Laundry/dry cleaner	Laundry/dry cleaner	Service	Miscellaneous
Library	Library	Public assembly	Miscellaneous
Lodging/hotel/motel	Lodging/hotel/motel	Lodging	Lodging
Logging and wood product manufacturing	General manufacturing	Manufacturing/food processing	Miscellaneous
Market rate multifamily	Multifamily	Multifamily	Multifamily
Meeting/convention center/hall or community center	Meeting/convention center/hall or community center	Public assembly	Miscellaneous
Middle school	K−12 school	K−12 school/ education	K−12 school/ education
Military (armory, etc.)	Military (armory, etc.)	Other	Miscellaneous
Multifamily	Multifamily	Multifamily	Multifamily
Office	Office	Office	Office
Parking structure/garage	Parking structure/garage	Parking/ transportation	Parking/ transportation
Place of worship	Place of worship	Religious worship	Miscellaneous
Police	Police	Public safety	Miscellaneous
Pre-K/daycare	Pre-K/daycare	K−12 school/ education	K−12 school/ education
Primary school	K−12 school	K−12 school/ education	K−12 school/ education

Market name	Market type[5]	Building type	Sampling type
Repair/maintenance shop	Repair/maintenance shop	Service	Miscellaneous
Retail	Retail	Mercantile	Miscellaneous
Transportation infrastructure (tunnel, roadway, dock, etc.)	Transportation infrastructure (tunnel, roadway, dock, etc.)	Parking/ transportation	Parking/ transportation
Vocational school/community classrooms	Vocational school/community classrooms	K−12 school/ education	K−12 school/ education
Warehousing and storage	Warehousing and storage	Warehouse	Miscellaneous
Water supply and sewage facilities	Water supply and sewage facilities	Other	Miscellaneous

3.5.2 Sample Sizes

Sampling occurred across four stratifications based on the required sample sizes. PPS sampling for both gas and electric savings was used to select projects within each stratification of the sample. Table 10 through

Table 13 show the necessary sample sizes to meet the desired relative precision, calculated by following the California Evaluation Framework.[6]

Table 10. Minimum Sample Sizes for Building Types (90/15 Confidence/Precision)

Building type	Projects	Reportable kWh savings	Reportable therms savings	Minimum sample size
Multifamily	139	17,856,034	214,281	14
Data center	4	3,356,191	0	3
Miscellaneous	202	8,029,376	73,485	14
College/university	20	3,904,371	23,882	9
Office	90	4,870,399	48,899	13
K-12 school/education	86	5,500,274	179,152	13
Parking/transportation	10	2,982,309	5,589	8
Lodging	35	2,381,835	50,809	11
Hospital/healthcare	33	2,244,831	32,658	15
Food service	50	242,729	40,257	12
Total	**669**	**51,368,350**	**669,010**	**112**

[6] https://www.calmac.org/publications/California_Evaluation_Framework_June_2004.pdf

Table 11. Minimum Sample Sizes for Program Track (90/15 Confidence/Precision)

Program track	Projects	Reportable kWh savings	Reportable therms savings	Minimum sample size
System-Based	522	22,078,652	269,265	29
Market Solutions	109	15,903,675	202,111	24
Data Center	4	3,356,191	0	4
Whole Building	19	5,290,345	121,018	13
Path to Net Zero	15	4,739,486	76,616	11
Total	**669**	**51,368,350**	**669,010**	**81**

Table 12. Minimum Sample Sizes for Building Codes (90/15 Confidence/Precision)

Building code	Projects	Reportable kWh savings	Reportable therms savings	Minimum sample size
2014	228	32,281,622	407,669	27
2019	384	18,428,406	245,932	28
2021	57	658,322	15,409	20
Total	**669**	**51,368,350**	**669,010**	**75**

Table 13. Minimum Sample Sizes for Program Year (90/10 Confidence/Precision)

Program year	Projects	Reportable kWh savings	Reportable therms savings	Minimum sample size
2021	357	30,430,584	351,107	57
2022	312	20,937,766	317,904	56
Total	**669**	**51,368,350**	**669,010**	**113**

The key stratifications were by building type and program year, with both requiring a minimum total of 113 sample points to meet the desired confidence and precision levels. After conducting sampling across all four strata, 119 projects were required to achieve the minimum sample sizes due to the crossover between categories.

3.6 ENGINEERING DESK REVIEWS AND ANALYSIS

After sample selection, the Tetra Tech team provided Energy Trust with a data request for all documentation for sampled sites, including specification sheets, measurements conducted pre- and post-installation, photographs, utility regressions, simulation models, and any other relevant project materials. These sampled projects underwent in-depth reviews of project baselines, savings calculations, supporting documentation, and accurate representations in the tracking system. The engineering desk reviews provided valuable feedback and insight into the overall program performance, including quality of project applications, consistency in project documentation, adherence to industry standards for data collection (e.g., ENERGY STAR and Air Conditioning, Heating and Refrigeration Institute (AHRI) certificates for equipment), calculation methodologies, and potential data gaps. The engineering desk reviews were used to determine the data collection necessary for the site-specific evaluation plan.

3.7 MEASUREMENT AND VERIFICATION

The Tetra Tech team viewed the M&V as a staged activity starting with the desk review, followed by a facility operator interview, and finally, a site visit. Based on the outcome of the desk review and operator interview, the Tetra Tech team drafted a site-specific M&V plan (SSMVP) for each project. The SSMVP outlined the available data and methods proposed and agreed upon for installation verifications and gathering key parameters to estimate the project's realized energy and demand savings. Some simple projects only required equipment verification and gathering of operating parameters. However, for most systems, the approach was determined by the International Performance Measurement and Verification Protocol (IPMVP), with systems and data prioritized based on the potential effect for savings. The most complex projects received short-term measurements, requests for access to utility data, and site data collection of parameters in the verification activities.

3.8 SIMULATION MODEL ANALYSIS

The verification method for sites that relied on energy simulation modeling conducted by PMC staff or program allies followed the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Appendix G guidelines for calibrated simulations. The calibration was primarily driven by utility billing data and supplemented by EMS and metered data for key energy systems. Energy simulations were calibrated using actual weather data, and final verified results were analyzed using normalized weather datasets.

In cases where EMS or metered data were obtained for key systems within the building, calibrating the simulation model was completed at the system level to match key characteristics before moving to the whole building level. The goal was to simulate the energy performance of individual systems to a reasonable amount of annual energy use, typically ±10 percent of annual energy use values, and then rational manipulations of unverified parameters were made to calibrate the remainder of the simulation. Typically, calibrated simulations were considered good when they were within ten percent of all annual energy metrics at the building meter level.

3.9 ESTIMATES OF SAVINGS

Analysis of information collected during primary data collection informed realization rates for each sampled site. Site-level results were weighted by electric or gas savings to accurately represent savings for the program population by measure category, fuel, and track. Energy savings for projects were adjusted for a variety of factors; examples include measures that were never installed, incorrect baselines, differences between assumed and actual use characteristics (such as operating hours), corrections to engineering algorithms, and direct measurement of key parameters.

To calculate the realization rate, the sum of the ex-post estimate of savings is divided by the sum of the ex-ante savings per the following equation:

$$RR = \frac{\sum_{i=1}^{n} BE_i}{\sum_{i=1}^{n} GSE_i}$$

Where RR is the realization rate, BE_i is the best estimate based on impact evaluation activities, and GSE_i is the ex-ante gross savings. This analysis is completed at the site level and then weighted to provide results at the program, track, and major measure category level. Due to the population weighting of results, the realization rates shown in Section 4.1 through Section 4.5 will not match the results for population weighting presented in Section 1.0 and Section 4.8.

3.10 ENERGY USE INTENSITY ANALYSIS

After receiving energy use data as part of the data collection activities, the Tetra Tech team calculated electric and gas EUIs in native units (e.g., kilowatt-hour and therms) and converted electric and gas consumption data into a single unit, kiloBtus (kBtu), allowing a straightforward comparison of the total energy consumed at the project site. After summing the total kBtu consumed at each site across the period provided, we divided the total kBtu by square footage to arrive at the estimated EUI at the site level.

The Tetra Tech team examined each dataset for completeness and accuracy with respect to the projects. Only projects with full datasets for both fuels and for which the datasets matched the project boundary were included for analysis. The site EUIs were then compared to the median EUIs from ENERGY STAR’s website, and an area-weight average was calculated across all of the projects.

4.0 IMPACT EVALUATION

The following sections detail the results of the impact evaluation by segmented populations.

4.1 SYSTEM-BASED

The System-Based track offers a combination of prescriptive- and custom-calculated measures for individual systems within a building. For 2021−2022, the System-Based track represented approximately 33 percent of the ex-ante kilowatt-hour savings and 40 percent of the ex-ante therms savings.

The Tetra Tech team reviewed 67 System-Based projects. Table 14 shows the breakdown of System-Based projects by program year and building code.

Table 14. Evaluated Results for the System-Based Track[7]

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2021	2014	20	76	3,877,565	32,446	3,548,704	29,342	92%	90%
	2019	12	33	396,508	12,662	395,184	12,662	100%	100%
	2021	1	1	0	1,293	0	1,293	N/A	100%
2021 total		**33**	**110**	**4,274,073**	**46,401**	**3,977,123**	**43,297**	**93%**	**93%**
2022	2014	2	7	143,741	3,092	132,182	2,606	92%	84%
	2019	14	56	672,773	50,440	564,444	33,468	84%	66%
	2021	18	26	255,196	7,609	222,853	7,734	87%	102%
2022 total		**34**	**89**	**1,071,710**	**61,141**	**922,172**	**43,809**	**86%**	**72%**
Grand total		**67**	**199**	**5,345,783**	**107,541**	**4,899,295**	**87,106**	**92%**	**81%**

Major findings for measure categories under the System-Based track are presented in the following sections.

4.1.1 Variable Refrigerant Flow

The EM&V team reviewed one variable refrigerant flow project at a college/university that had two *condenser models* incented. One of the models was found to not meet the requirements of Consortium for Energy Efficiency (CEE) Tier 1. The prescriptive savings from the measure approval document (MAD), which are based on per-square-foot values, were removed for this condenser unit, and an alternative calculation was used based on the actual efficiency of the installed unit and the baseline efficiency. This resulted in a 62 percent realization rate for the kilowatt-hour savings on this measure and was the largest single kilowatt-hour savings adjustment in the System-Based track.

[7] For the realization rate calculations in Section 4.8, a separately evaluated project (2022 program year, 2019 code), which resulted in realization rates of 92 percent for electric savings and 100 percent for therms savings, is included in the realization rate calculations.

4.1.2 Other

The EM&V team reviewed eleven projects that incented *other* measures under the System-Based track. Measures such as *kitchen exhaust hoods*, *energy recovery ventilators*, and *infrared heaters* were incented under this measure category. The largest adjustment was to an *energy recovery ventilator*, where the cooling and heating setpoints were adjusted, and the schedule of operation was reduced, based on the site representative interview. Adjustments to *other* measures included equipment operational schedule adjustments, setpoint adjustments, and removal of prescriptive savings for equipment that did not meet MAD requirements. Overall, this measure category resulted in a 68 percent realization rate for therms savings.

4.1.3 Tanked and Tankless Water Heaters

Tanked and *tankless water heaters* were incented at 26 of the 67 System-Based projects in the sample. Nineteen of the 26 projects did not have adjustments to the savings from the evaluation. The largest adjustment was for a hotel where coin-operated laundry was claimed, while the MAD treats coin-operated laundry as a stand-alone business and not as a subset of the *hotel* building type. Another large adjustment was for a hotel that had not completed construction by the time of this evaluation report. There were smaller capacity adjustments from model nameplates and specifications sheets and one project with a building type adjustment. Overall, the *tanked* and *tankless water heaters* resulted in a 75 percent realization rate for therms savings.

4.1.4 Server Closet Mini-Split

Server closet mini-splits were incented at 13 projects in the System-Based track. Eight of the 13 projects had no adjustments from the evaluation. The largest adjustment was for a parking garage that installed multiple *mini-split* units that were not used exclusively for data center equipment. Another project installed units that did not meet the minimum seasonal energy efficiency ratio (SEER) requirement for the MAD. Overall, the mini-splits resulted in a 21 percent realization rate for kilowatt-hour savings. Excluding the project with non-qualified units, the savings for the *mini-splits* result in an 88 percent realization rate for kilowatt-hour savings.

4.1.5 Food Equipment

Food equipment was incented at 21 projects in the System-Based track. For 19 of the 21 projects, no adjustments were made from the evaluation. For two projects, savings were removed because a *hotel* still had not completed construction at the time of the evaluation, and a *food service* site burned down during the evaluation. Overall, *food equipment* resulted in realization rates of 61 percent for kilowatt-hour and 79 percent for therms savings.

4.2 MARKET SOLUTIONS

The Market Solutions track offers incentives for improving the overall efficiency of the building design for both new construction and major renovation projects. The offering covers building energy uses, including *envelope*, *HVAC*, *domestic hot water (DHW)*, *lighting*, and *appliances*. For 2021−2022, Market Solutions represented approximately 24 percent of the ex-ante kilowatt-hour savings and 30 percent of the ex-ante therms savings.

The Tetra Tech team reviewed 24 Market Solutions projects across multifamily (21) and food service (3) building types. Table 15 shows the breakdown of Market Solutions projects by program year and building code.

Table 15. Evaluated Results for the Market Solutions Track

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante Therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2021	2014	9	97	1,862,334	54,129	1,732,728	53,361	93%	99%
	2019	6	53	536,350	15,686	225,166	11,286	42%	72%
2021 total		**15**	**150**	**2,398,684**	**69,815**	**1,957,894**	**64,647**	**82%**	**93%**
2022	2014	3	34	497,872	14,168	471,520	14,443	95%	102%
	2019	5	60	1,281,500	12,210	909,234	14,453	71%	118%
	2021	1	7	91,933	0	67,920	0	74%	N/A
2022 total		**9**	**101**	**1,871,305**	**26,378**	**1,448,674**	**28,896**	**77%**	**110%**
Grand total		**24**	**251**	**4,269,989**	**96,193**	**3,406,569**	**93,543**	**80%**	**97%**

Major findings for measure categories under the Market Solutions track are presented in the following sections.

4.2.1 Multifamily Market Solutions Offering for 2019 and 2021

Eight of the multifamily Market Solutions projects reviewed were permitted under the Oregon 2019 building code, and one multifamily project was permitted under the Oregon 2021 building code. These 2019 and 2021 code projects utilized EnergyPlus models (created through ModelKit) to estimate energy savings for various measures in new construction multifamily projects. For each project, a baseline model (based on code-compliant prototypes) and a final design model (incorporating energy-efficient features of the building) were created. The energy consumption of the two models was compared and scaled by building area to claim energy savings. The Tetra Tech team reviewed seven mid-/high-rise[8] multifamily buildings and two low-rise[9] multifamily buildings. Based on this review, the following conclusions were reached:

Many measures had unclear modeling translations and may be better calculated through prescriptive paths. Tetra Tech recommends that several measures included in the EnergyPlus models be removed in future iterations of this program, as their translations between ModelKit and EnergyPlus were unclear and undocumented. These measures also have minimal interactive effects and do not scale well by area. The measures in question include *faucet aerators*, *clothes washers*, *dishwashers*, *dryers*, *efficient exhaust fans*, *exterior lighting*, *refrigerators*, and *tankless water heaters*. For the evaluation, Tetra Tech recalculated these measures using prescriptive methodologies from the Minnesota Technical Resources Manual (*aerators*), ENERGY STAR® certifications (*dishwashers* and *refrigerators*), ENERGY STAR simulation guidelines (*clothes washers*), and Energy Trust MAD prescriptive methodologies (*dryers, exhaust fans, exterior lighting,* and *tankless water heaters*). Removing these measures would also allow for a more precise accounting of energy savings, particularly in multifamily buildings where (1) some appliances are only present in a subset of total apartments or (2) many apartments have multiple bathroom faucets and ventilation fans.

Lighting savings were claimed for projects even if they were not selected. *Exterior lighting* savings were included for all seven mid/high-rise projects despite not being selected in the application and having no documentation. Similarly, interior in-unit lighting savings were claimed for four mid/high-rise projects even though they were not selected in the application and had no documentation. The ModelKit/EnergyPlus translation should be reviewed to ensure no lighting energy savings are claimed when not intended to be incented.

[8] Mid- and high-rise buildings are greater than three floors and are subject to the commercial energy code.
[9] A low-rise building is between one to three floors and is subject to the residential energy code.

Corridor lighting savings were claimed for projects even though it was not approved in the MAD. *Corridor lighting* savings were included for all seven mid/high-rise projects. Although prescriptive savings could be claimed for two projects with sufficient documentation, documentation was insufficient for the other five projects. *Corridor lighting* should be added to the MAD, and sufficient documentation (lighting plans, specification sheets, calculators) should be provided for projects claiming *corridor lighting* savings.

HVAC modeling on complex buildings should be more clearly defined. The modeling of *HVAC* equipment in the 2019 and 2021 Market Solutions projects was unclear and inconsistent, particularly in buildings with central rooftop units in addition to in-unit HVAC equipment. For example, in one project, the final design model excluded the *ductless heat pumps* in each apartment unit and only modeled an *energy recovery ventilation (ERV) system* serving the common areas. For two projects, the ERV system was modeled within EnergyPlus, but in another project, the ERV system was modeled using a custom calculation outside the model. In one project, the EnergyPlus model also failed to capture the fact that the apartments were cooled by a combination of the building's ERV system and room air conditioning units. To enhance clarity and understanding in buildings with multiple *HVAC* systems, an explanation or rationale of the systems input into the final design model should be provided.

HVAC modeling inputs were inconsistent with code values and installed equipment efficiencies. Many projects had adjustments to the *HVAC* baseline and final design cooling and heating efficiencies, as the efficiencies in the EnergyPlus model did not match those specified by code (IECC 2018 for low-rise or ASHRAE 90.1 Appendix G for mid/high-rise), the application, or the documentation. The evaluation team recommends additional quality assurance/quality control or a review of the ModelKit to EnergyPlus translation for *HVAC* units to ensure that the correct efficiencies are reflected in both the baseline and final design models.

In-unit lighting documentation was incomplete or inconsistent. Four of the five projects that claimed *lighting power density* (*LPD) reduction in living units* had their LPD adjusted because the total wattage installed in the apartments and the in-unit area calculated by the evaluation team did not match the reported values. One project used the 2019 prescriptive lighting calculator, two selected representative units that did not reflect the entire multifamily building, and one used a ComCheck markup to calculate LPD savings. Adopting a consistent calculation process that accounts for all units within the multifamily building and systematically tabulates wattages for *in-unit lighting* to reflect changes from building design drawings to as-built conditions would improve the consistency and accuracy of energy savings. Additionally, two of these projects lacked documentation related to *in-unit lighting*. Collecting specification sheets and in-unit as-built lighting plans is necessary to verify the claimed interior lighting savings.

Wall insulation inputs were inconsistent with the code and installed equipment. *Wall insulation* appeared to be incorrectly inputted into the EnergyPlus models, requiring evaluation adjustments for every project reviewed. In two low-rise buildings, the baseline R-value was not modeled according to IECC 2018 code requirements. All nine Market Solutions projects reviewed required adjustments to the final design R-value, with seven adjustments made to achieve the desired final R-value specified in the documentation and two adjustments made to set the final R-value equal to the baseline R-value due to insufficient documentation supporting the installed *wall insulation*.

Window-to-wall ratio savings should not be modeled. Savings associated with window-to-wall ratio were claimed for four mid-/high-rise multifamily buildings, despite ASHRAE 90.1 Appendix G specifying that baseline and final design window-to-wall ratios should be set equal for building types not listed in Table G3.1.1-1. Since *multifamily* is not listed in the table, savings from this measure should not be modeled in EnergyPlus or claimed by the program.

Low-rise multifamily models did not follow IECC 2018. According to MAD 258.1 (for Multifamily Market Solutions 2019 code), four different baseline EnergyPlus models were created for low-rise multifamily buildings for four different scenarios (electric heat, electric DHW; electric heat, gas DHW; gas heat, electric DHW; and gas heat, gas DHW). These models, even though they were specified to be compliant with IECC 2018, differed from the low-rise multifamily prototype models created by the DOE, with efficiency ratings differing from the climate-zone-specific prototype models built by the DOE. Documentation on how these four models were constructed and altered for each specific project was unavailable for review. Additionally, Tetra Tech found instances in both low-rise multifamily projects that were reviewed where ASHRAE 90.1 Appendix G values were used in the baseline model instead of IECC 2018 code or prototype models, including the efficiencies used for *HVAC* and *insulation* measures.

The following measure category findings are for non-multifamily buildings and multifamily buildings that did not use ModelKit as the primary basis for savings.

4.2.2 Custom Other

There were nine projects that incented *custom other* measures under the Market Solutions track. Measures included *frictionless elevators*, *high-performance bath fans*, *air barriers*, *variable frequency drives (VFD) with carbon monoxide monitoring*, *high-performance lighting*, and *ENERGY STAR appliances*. The largest adjustments were for two measures (*high-performance lighting* and *ENERGY STAR clothes washers*) at a single project that did not collect sufficient documentation during the implementation of the project, and the site visit was unable to support the level of efficiency. Other adjustments included claiming an incorrect baseline efficiency for the *VFD with carbon monoxide monitoring*, quantity reductions from design drawing reviews, and applying historical occupancy rates for elevators at an apartment building. Overall, this measure category resulted in a 93 percent realization rate for kilowatt-hours and an 84 percent realization rate for therms.

4.2.3 Custom HVAC

There was one project that incented *custom HVAC* measures under the Market Solutions track. For this project, one measure was not intended to be claimed, according to the implementer. For the other measure, the heating and cooling setpoints for an *ERV* were adjusted based on the site visit. Overall, this measure category resulted in a 32 percent kilowatt-hour realization rate.

4.2.4 Air Sealing

Nine projects incented *air sealing* measures under the Market Solutions track. For two *air barrier* measures, measure area adjustments were made from the project drawings, which reduced energy savings. Overall, this measure resulted in a 92 percent kilowatt-hour realization rate.

4.2.5 Tanked and Tankless Water Heaters

Twelve projects incented tanked or *tankless water heaters*. The largest adjustment was from a project that claimed *tankless water heater* deemed values when *tanked water heaters* were installed, which reduced savings.

Multiple projects had an increase in their evaluated savings. One project had 199 kBtuh claimed for water heater capacity for each water heater when the units installed were actually 499 kBtuh. Two projects claimed a quantity of water heaters (one and five, respectively) when additional water heaters were installed at the project (totals of three and ten). Finally, the deemed building type for one project was adjusted from *school* to *restaurant*, which increased savings by 72 percent. Overall, adjustments for this measure category resulted in a 108 percent realization rate for therms.

4.2.6 Faucet Aerator

Twelve projects incented *faucet aerators* under the Market Solutions track. For four projects, adjustments were made based on the measured flow rates during site inspections. Other adjustments included the quantity of fixtures installed based on drawings for two projects and deemed savings factors adjusted for the MAD version in place at the time of the project's permit. Overall, adjustments for this measure category resulted in 86 percent realization rates for kilowatt-hours and therms.

4.3 DATA CENTER

The Data Center track offers support for the specific needs in the construction of new data centers. The program offers incentives for improved energy efficiency of *HVAC* measures and *power distribution systems*. For 2021−2022, a total of five Data Center projects were completed, representing 21 percent of ex-ante kilowatt-hour savings and no therms savings.

The Tetra Tech team reviewed three Data Center projects. Table 16 shows the breakdown of Data Center projects by program year and building code.

Table 16. Evaluated Results for the Data Center Track[10]

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2021	2019	1	1	671,796	0	671,796	0	100%	N/A
2022	2019	2	2	14,010	0	16,386	0	117%	N/A
Total		**3**	**3**	**685,806**	**0**	**688,182**	**0**	**100%**	**N/A**

For the three Data Center projects analyzed, one used whole-building modeling in Integrated Environmental Solutions Virtual Environment (IESVE)[11], while two other projects used spreadsheet-based custom calculations. All savings results for these projects were reported under the *custom HVAC* or *custom other* measure descriptions.

The Data Center track had one adjustment to savings. From the site visit, the temperature setpoint for the data center was noted as 68ºF rather than 72ºF from the ex-ante calculations. This adjustment resulted in a 129 percent kilowatt-hour realization rate for this project.

Overall, the Data Center track had a 100 percent realization rate.

4.4 WHOLE BUILDING

The Whole Building path provides a performance pathway in alignment with the 2019 Oregon Zero Energy Ready Commercial Code (OZERCC) and 2021 Oregon Energy Efficiency Specialty Code (OEESC). Whole Building provides a multi-incentive application process for whole-building energy modeling, early design assistance, technical design assistance, installed energy-efficient design features, and energy metering. For 2021−2022, Whole Building represented approximately 13 percent of the ex-ante kilowatt-hour savings and 18 percent of the ex-ante therms savings.

The Tetra Tech team reviewed and analyzed ten Whole Building projects. Table 17 shows the breakdown of Whole Building projects by program year and building code.

[10] For the realization rate calculations in Section 4.8, a separately evaluated project (2014 code), which resulted in 73 percent realization for electric savings, is included in the realization rate calculation.
[11] https://www.iesve.com/

Table 17. Evaluated Results for the Whole Building Track

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2021	2014	4	12	634,151	31,636	600,651	28,447	95%	90%
2021 total		**4**	**12**	**634,151**	**31,636**	**600,651**	**28,447**	**95%**	**90%**
2022	2014	5	27	1,961,408	59,643	1,983,162	41,260	101%	69%
	2019	1	3	0	19,379	0	19,608	N/A	101%
2022 total		**6**	**30**	**1,961,408**	**79,022**	**1,983,162**	**60,868**	**101%**	**77%**
Grand total		**10**	**42**	**2,595,559**	**110,658**	**2,583,813**	**89,315**	**100%**	**81%**

The evaluation team found three software packages used for the analysis of the reviewed Whole Building track projects; five projects that used The Quick Energy Simulation Tool (eQUEST)[12], two used EnergyPlus[13], and three used IESVE, which are all industry-standard software packages.

For the 2014 code projects, baseline energy models used the 2014 OSEEC code. For the 2019 code project, the baseline was modeled to ASHRAE 90.1-2016 Appendix G, which approximates an ASHRAE 90.1-2004 code-compliant building and end-use ratios supplied by the Pacific Northwest National Laboratory (PNNL)[14], were used to adjust between energy codes.

Overall, the evaluation found that the adherence to the modeling guidelines, industry-standard modeling techniques, and code-specified values was strong. The largest adjustments to the Whole Building track were for measures that included positive energy savings on one of the fuels but did not claim the interactive negative energy savings on the other fuel; this stemmed from guidance in the program manual to include negative savings amounts in the attribute data but not to report them directly as energy savings. This policy was adjusted by Energy Trust in 2023. This practice makes sense for prescriptive measures, but for whole building projects where measures are aggregated at the building level for analysis and then separated through parametric or other model runs into individual measures, not including the negative savings caused the overall project savings to be overstated.

Results of individual projects are presented below using an anonymized reporting ID.

4.4.1 Reporting ID 6

This project is a 2014 code project modeled in eQUEST that reported savings for *custom HVAC*, *custom lighting*, and *other measures*, and *server closet mini-split AC units* at a *K−12 school/education* building type. The evaluation team made slight adjustments to the *LPD* resulting from the in-person site visit. In the evaluated savings, negative kilowatt-hour savings were included for the *custom HVAC* measure, and negative therms savings were included for the *custom lighting* measure. These adjustments resulted in realization rates of 38 percent for kilowatt-hours and 94 percent for therms savings.

[12] https://doe2.com/equest/
[13] https://energyplus.net/
[14] http://www.energycodes.gov/sites/default/files/documents/2016EndUseTables.zip

4.4.2 Reporting ID 9

This project is a 2014 code project modeled in EnergyPlus that reported savings for *custom HVAC, custom insulation, custom lighting,* and *custom other* at a *service* building type. The radiant chilled water-loop pump head pressure was adjusted from 60 to 80 psig, per the mechanical schedule. The boiler thermal efficiency was adjusted from 0.962 to 0.952, per the AHRI certification. Finally, negative savings for *skylights*, *interior lighting*, and *service hot water* were included in the ex-post evaluated savings. These adjustments resulted in realization rates of 100 percent for kilowatt-hours and 32 percent for therms.

4.4.3 Reporting ID 10

This project is a 2014 code project modeled in IESVE that reported savings for *custom gas, custom HVAC, custom insulation,* and *custom lighting* at an *office* building type. The in-person site visit found multiple areas with fixture quantities and wattages that exceeded those modeled in the proposed energy model and were adjusted in the ex-post proposed model. Also, there were unclaimed negative savings for therms for the *custom lighting* measure, which were included in the ex-post savings estimate. These adjustments resulted in realization rates of 97 percent for kilowatt-hours and 78 percent for therms.

4.4.4 Reporting ID 11

This project is a 2014 code project modeled in IESVE that reported savings for *custom HVAC, custom lighting,* and *custom other* at a *hospital/healthcare* building type. Several parameters were adjusted for the baseline and proposed model envelopes. The baseline model had a wall U-value of 0.064 tracked, which was updated to 0.125 to align with the model review summary worksheet. The baseline windows had a U-value of 0.47 and a solar heat-gain coefficient (SHGC) of 0.45, which were adjusted to 0.45 and 0.40, respectively. The baseline roof had a U-value of 0.048, which was updated to 0.063. The proposed model included the same envelope parameters as the baseline model. These were updated to 0.044 U-value for the walls, 0.35 U-value and 0.33 SHGC for the windows, and 0.029 U-value for the roof to align with the model review summary worksheet. These adjustments resulted in a realization rate of 118 percent for kilowatt-hours.

4.4.5 Reporting ID 15

This project is a 2014 code project modeled in IESVE that reported savings for *custom gas, custom HVAC, custom lighting, custom other, dishwasher,* and *food equipment* at a *K−12 school/education* building type. The *dishwasher* and *food equipment* measures were calculated outside the energy model and had 100 percent realization rates. For the energy model, the evaluation team found multiple systems with unmet load hours (UMLH) that were above a typical threshold. The modeler was able to resolve the UMLH by adjusting the ERV system controls and variable-air-volume reheat controls, as well as upsizing heating airflow to meet demand. *Custom lighting* had negative therms savings that were not included in the ex-ante savings. The adjustments for this project resulted in realization rates of 106 percent for kilowatt-hours and 58 percent for therms.

4.4.6 Reporting ID 28

This project is a 2014 code project modeled in eQUEST that reported savings for *custom lighting* and *custom other* at a *college/university* building type. A quantity adjustment was made for lighting fixtures for a plan change from the as-built drawings. A wattage adjustment for one fixture was applied from the DesignLight Consortium listings. The adjustments for this project resulted in a realization rate of 100 percent for kilowatt-hours.

4.4.7 Reporting ID 29

This project is a 2014 code project modeled in eQUEST that reported savings for *custom HVAC* and *custom lighting* at a *public safety* building type. Two lighting areas had *LPD* values that did not correspond with the measure baselines. The *custom lighting* had negative therms savings, while the *custom HVAC* had negative kilowatt-hour savings that were not included in the ex-ante savings. The adjustments for this project resulted in realization rates of 94 percent for kilowatt-hours and 84 percent for therms.

4.4.8 Reporting ID 31

This project is a 2014 code project modeled in EnergyPlus that reported savings for *custom gas, custom HVAC, custom insulation, custom lighting,* and *food equipment* at a *K−12 school/education* building type. The *food equipment* measure was calculated outside the energy model and had a 100 percent realization rate. The *custom lighting* measure had negative therms savings, while the *custom HVAC* and *custom gas* measures had negative kilowatt-hour savings that were not included in the ex-ante savings. The adjustments for this project resulted in realization rates of 98 percent for kilowatt-houurs and 97 percent for therms.

4.4.9 Reporting ID 34

This project is a 2014 code project modeled in eQUEST that reported savings for *custom HVAC, custom lighting,* and *other measure* at a *hospital/healthcare* building type. The *custom lighting* measure had negative therms savings that were not included in the ex-ante savings. The adjustment for this project resulted in realization rates of 100 percent for kilowatt-hours and 62 percent for therms.

4.4.10 Reporting ID 58

This project is a 2019 code project modeled in eQUEST that reported savings for *custom HVAC, custom other,* and *domestic hot water* at a *hospital/healthcare* building type. No adjustments were made to model inputs, but changing the simulation engine from DOE-2.2-48y to DOE-2.2-50a resulted in slight discrepancies. This project resulted in realization rates of 101 percent for kilowatt-hours and 84 percent for therms.

4.5 PATH TO NET ZERO

Path to Net Zero (PTNZ) is an extension of the Whole Building track. In addition to the multi-incentive process, PTNZ provides incentives for achieving PTNZ status by meeting energy use intensity (EUI) goals that meet or exceed the Architecture 2030 Challenge Guidelines. For 2021−2022, PTNZ represented approximately 9 percent of the ex-ante kilowatt-hour savings and 11 percent of the ex-ante therms savings.

The Tetra Tech team reviewed six PTNZ projects. Table 18 shows the breakdown of PTNZ projects by program year and building code.

Table 18. Evaluated Results for the Path to Net Zero Track

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2021	2014	4	25	2,359,902	53,549	2,392,798	47,966	101%	90%
	2019	1	1	19,648	789	20,059	715	102%	91%
2021 total		**5**	**26**	**2,379,550**	**54,338**	**2,412,857**	**48,681**	**101%**	**90%**

Program year	Building code	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
2022	2014	1	4	350,042	0	367,248	0	105%	N/A
2022 total		**1**	**4**	**350,042**	**0**	**367,248**	**0**	**105%**	**N/A**
Grand total		**6**	**30**	**2,729,592**	**54,338**	**2,780,105**	**48,681**	**102%**	**90%**

Similar to the Whole Building track, the evaluation team found three software packages used for analysis on the PTNZ projects: one project used eQUEST, one used EnergyPlus, and four used IESVE.

For the 2014 code projects, baseline energy models used the 2014 OSEEC code. For the 2019 code project, the baseline was modeled to ASHRAE 90.1-2016 Appendix G, which approximates an ASHRAE 90.1-2004 code-compliant building. End-use ratios supplied by PNNL were used to adjust between energy codes.

Overall, the evaluation found that adherence to the modeling guidelines, industry-standard modeling techniques, and code-specified values was strong. The largest adjustments to the PTNZ track were for measures that included positive energy savings on one of the fuels but did not claim the interactive negative energy savings on the other fuel; this stemmed from guidance in the program manual to include negative savings amounts in the attribute data but not to report them directly as energy savings. This practice makes sense for prescriptive measures, but for whole building projects where measures are aggregated at the building level for analysis and then separated through parametric or other model runs into individual measures, not including the negative savings caused the overall project savings to be overstated.

Results of individual projects are presented below using an anonymized reporting ID.

4.5.1 Reporting ID 1

This project is a 2019 code project modeled in IESVE that reported savings for *custom other* at a *college/university* building type. The baseline model included window parameters of 0.47 U-value and 0.45 SHGC, which were adjusted to 0.45 U-value and 0.40 SHGC to align with the prescriptive components of ASHRAE 90.1-2016 Appendix G. The baseline HVAC system parameters were updated from 9.5 EER to 10.1 EER for systems between 65 kBtuh and 135 KBtuh. The baseline fan power for the outside air ventilation system was 0.21 W/cfm, which was adjusted to 0.77 W/cfm by following the fan power requirements of ASHRAE 90.1.

The proposed model had multiple parameters adjusted to reflect the actual building design. The exterior walls were adjusted from 0.064 U-value to 0.044 U-value. The roof parameters were adjusted from 0.048 U-value to 0.029 U-value. The window parameters were adjusted from 0.47 U-value and 0.45 SHGC to 0.35 U-value and 0.33 SHGC. Finally, the *LPD* was adjusted from 1.09 Watts per square foot (which is the baseline value) to 0.466 by the space-by-space method.

Overall, these adjustments resulted in realization rates of 102 percent for kilowatt-hours and 91 percent for therms savings.

4.5.2 Reporting ID 14

This project is a 2014 code project modeled in IESVE that reported savings for *custom gas, custom HVAC, custom lighting,* and *dishwasher* at a *K−12 school/education* building type. The *dishwasher* measure was calculated outside the energy model and had a 100 percent realization rate. The *custom lighting* measure had negative therms savings that were not included in the ex-ante savings. This adjustment resulted in realization rates of 100 percent for kilowatt-hours and 71 percent for therms savings.

4.5.3 Reporting ID 18

This project is a 2014 code project modeled in eQUEST that reported savings for *custom HVAC, custom lighting,* and *custom other* at an *office* building type. Multiple adjustments were made from control system data obtained during the in-person site visit. The radiant chilled water-loop setpoint was adjusted from 50ºF to 58ºF. The hot water-loop setpoint was adjusted from 140ºF to 115ºF. The radiant hot water-loop setpoint was adjusted from 140ºF to 110ºF. Finally, the *custom lighting* measure had negative therms savings that were not included in the ex-ante savings. Overall, this project resulted in realization rates of 105 percent for kilowatt-hours and 95 percent for therms.

4.5.4 Reporting ID 22

This project is a 2014 code project modeled in IESVE that reported savings for *custom HVAC, custom lighting,* and *custom other* at an *office* building type. No adjustments were made to model inputs, but changing the version of IESVE resulted in discrepancies. This project resulted in a realization rate of 105 percent for kilowatt-hours.

4.5.5 Reporting ID 23

This project is a 2014 code project modeled in IESVE that reported savings for *custom gas, custom HVAC, custom insulation, custom lighting, dishwasher,* and *food equipment* at a *K−12 school/education* building type. The *dishwasher* and *food equipment* measures were calculated outside the energy model and had 100 percent realization rates.

For the energy model, three constructions were found in the proposed model that did not use the defined construction for the proposed envelope. These were adjusted to the wall and roof constructions for the proposed model, which resulted in slightly increased electric and therms savings. The DHW load in the proposed model did not match the defined inputs. The evaluator found that 20.04 gallons per hour (gph) was used while 14.90 gph was specified. The *custom lighting* and *custom insulation* measures had negative kilowatt-hour savings, and the *custom lighting* measure had negative therms savings that were not included in the ex-ante savings.

Overall, the adjustments resulted in realization rates of 94 percent for kilowatt-hours and therms.

4.5.6 Reporting ID 27

This project is a 2014 code project modeled in EnergyPlus that reported savings for *custom HVAC, custom insulation, custom lighting,* and *custom other* at a *college/university* building type. No adjustments were made to model inputs for this project. The energy use of the baseline and proposed model was adjusted proportionally based on the proposed model kilowatt-hour use (408,211 kWh) and 12 months of utility bills (380,800 kWh). This adjustment resulted in a realization rate of 104 percent for kilowatt-hours.

4.6 BUILDING TYPE FINDINGS

The building types from the tracking system were assigned to building sampling type groupings for sampling in accordance with Table 9. Table 19 below presents the results of the evaluation by building sampling types.

Table 19. Evaluated Results for Building Sampling Type

Sampling type	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
College/ university	7	29	1,229,335	5,113	1,136,747	4,547	92%	89%
Data center	3	5	685,806	0	688,182	0	100%	N/A
Food service	12	37	43,555	15,067	31,011	11,897	71%	79%
Hospital/ healthcare	15	46	1,807,530	37,125	1,646,504	26,457	91%	71%
K−12 school/ education	11	86	2,189,898	120,227	2,134,326	100,945	97%	84%
Lodging	11	78	1,161,449	30,257	821,098	27,203	71%	90%
Miscellaneous	16	63	1,281,732	37,859	1,305,277	32,411	102%	86%
Multifamily	18	212	3,438,277	80,704	2,860,490	76,043	83%	94%
Office	9	31	927,220	36,369	952,835	33,139	103%	91%
Parking/ transportation	8	20	2,863,294	6,142	2,781,494	6,003	97%	98%
Total	**110**	**607**	**15,628,095**	**368,863**	**14,357,963**	**318,645**	**92%**	**86%**

The building sampling types had realization rates between 71 and 103 percent on kilowatt-hours and 71 and 94 percent on therms. Therms realization rates were affected most by unclaimed negative savings on the Whole Building and PTNZ tracks. For *food service* and *lodging* building types, the savings were affected most by projects that did not complete construction or were no longer in operation.

4.7 MEASURE CATEGORY FINDINGS

Evaluation descriptions were organized into measure categories for reporting (see Appendix C for details). Table 20 presents the evaluation results by measure category.

Table 20. Sampled Results for Evaluation Measure Categories

Measure category	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
Appliance	27	39	155,353	17,143	152,171	17,426	98%	102%
Custom	49	117	8,339,768	202,880	7,700,753	165,363	92%	82%
Domestic hot water	43	84	40,670	95,181	38,989	89,857	96%	94%
Envelope	10	10	271,706	134	249,111	0	92%	0%
Food equipment	27	32	62,323	17,670	46,725	14,444	75%	82%

Measure category	Projects	Measures	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
HVAC	34	43	1,178,129	13,814	992,668	11,949	84%	86%
Lighting	63	93	4,943,390	0	4,622,199	0	94%	
Whole building	24	108	636,755	22,042	555,347	19,606	87%	89%
Total	**110**	**607**	**15,628,095**	**368,863**	**14,357,963**	**318,645**	**92%**	**86%**

The measure categories had realization rates between 75 and 98 percent on kWh and 82 and 94 percent on therms. Therms realization rates were affected most by unclaimed negative savings on the Whole Building and PTNZ tracks. For *food equipment*, the kWh savings were affected most by a project that was no longer in operation.

4.8 REALIZATION RATES

For the calculation of realization rates, the impact results across the strata for sampling were reviewed for common issues. For the Market Solutions and System-Based tracks, there were statistically significant results across program years and building codes to calculate realization rates separately. In the case of the 2019 and 2021 program codes, the results were aggregated for these tracks.

The evaluation team found savings variances were common across the Whole Building and PTNZ projects by code year. All of the Whole Building and PTNZ projects were combined into single realization rate categories for 2014 and combined 2019−2021 codes. Finally, the three projects for the Data Center track were included in the realization rate category for 2019 code Data Center projects, while the single large separately evaluated Data Center project is the lone project in the 2014 code data center category. Table 21 shows the evaluated results by realization rate categories.

Table 21. Sampled Results by Realization Rate Category[15]

Category	Projects	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
Data Center (2014 code)	1	2,547,831	1,849,404	0	0	73%	N/A
Data Center (2019 code)	3	685,806	0	688,182	0	100%	N/A
Market Solutions (2021, 2014 code)	9	1,862,334	54,129	1,732,728	53,361	93%	99%
Market Solutions (2021, 2019 code)	6	536,350	15,686	225,166	11,286	42%	72%
Market Solutions (2022, 2014 code)	3	497,872	14,168	471,520	14,443	95%	102%
Market Solutions (2022, 2019-2021 code)	6	1,373,433	12,210	977,154	14,453	71%	118%
System-Based (2021, 2014 code)	20	3,877,565	32,446	3,581,939	29,342	92%	90%

[15] In addition to the 110 evaluated projects, 2 separately evaluated projects are included in the realization rate tables. One Data Center (2014 code) project resulted in 73 percent realization for electric savings and one System-Based (2022, 2019-2021 code) project resulted in realization rates of 92 percent for electric savings and 100 percent for therms savings.

Category	Projects	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
System-Based (2021, 2019-2021 code)	13	396,508	13,955	395,184	13,955	100%	100%
System-Based (2022, 2014 code)	2	143,741	3,092	132,182	2,606	92%	84%
System-Based (2022, 2019-2021 code)	32	929,336	58,182	789,990	41,202	85%	71%
WB/PTNZ, 2014 Code	14	5,305,503	5,343,858	144,828	117,673	101%	81%
WB/PTNZ, 2019 Code	2	19,648	20,059	20,168	20,323	102%	101%
Total	**112**	**20,292,607**	**18,144,591**	**369,141**	**318,922**	**89%**	**86%**

Table 22 shows the results of the realization rate categories weighted for the full population for the 669 projects in the sample frame. The population-weighted savings resulted in overall realization rates of 91 percent for kilowatt-hours and 88 percent for therms.

Table 22. Evaluated Savings by Realization Rate Category

Category	Projects	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
Data Center, 2014 Code	1	2,644,394	0	1,919,496	0	73%	N/A
Data Center, 2019 Code	3	711,798	0	714,264	0	100%	N/A
Market Solutions (2021, 2014 code)	46	6,686,092	115,549	6,220,786	113,910	93%	99%
Market Solutions (2021, 2019 code)	11	967,920	21,867	406,344	15,732	42%	72%
Market Solutions (2022, 2014 code)	20	3,417,792	43,380	3,236,895	44,223	95%	102%
Market Solutions (2022, 2019-2021 code)	32	4,831,871	21,316	3,437,722	25,232	71%	118%
System-Based (2021, 2014 code)	116	9,801,622	71,795	9,054,346	64,928	92%	90%
System-Based (2021, 2019-2021 code)	165	4,103,970	54,274	4,090,260	54,274	100%	100%
System-Based (2022, 2014 code)	22	1,549,526	20,567	1,424,917	17,336	92%	84%
System-Based (2022, 2019-2021 code)	219	6,623,534	122,629	5,930,301	87,011	90%	71%
WB/PTNZ, 2014 Code	23	8,182,196	156,377	8,241,349	127,057	101%	81%
WB/PTNZ, 2019 Code	11	1,847,635	41,257	1,886,284	41,573	102%	101%
Total	**669**	**51,368,350**	**669,010**	**46,562,964**	**591,276**	**91%**	**88%**

Realization rates were 42 to 101 percent for kilowatt-hours and 71 to 118 percent for therms. The realization rate category with the largest deviation in realization rates from 100 percent was Market Solutions for the 2021 program year and 2019 code, which resulted in realization rates of 42 percent for kilowatt-hours and 72 percent for therms. This was due to various issues in the ModelKit savings methodologies outlined in Section 4.2.1.

4.9 DEMAND ANALYSIS

For the demand analysis, the results of the impact analysis for individual projects were used as the basis for the evaluated savings. The load profiles for each measure from the ex-ante data were reviewed for accuracy and compared to the available load shapes; when a better fit for a load shape for the specific measure was present, the savings factors were adjusted. The results from the sampled projects were then applied to the entire population through sample-weighted realization rates by realization rate category.

Table 23 presents the realization rates by building type for the demand analysis.

Table 23. Demand Analysis Realization Rates by Building Type

Building type	PAC summer (kW)	PAC winter (kW)	PGE summer (kW)	PGE winter (kW)
College/university	105%	102%	94%	105%
Data center	100%	100%	100%	100%
Food service	81%	70%	80%	72%
Hospital/healthcare	100%	81%	100%	80%
K-12 school/education	100%	111%	110%	111%
Lodging	62%	58%	63%	59%
Miscellaneous	118%	91%	118%	93%
Multifamily	82%	80%	81%	78%
Office	143%	124%	140%	119%
Parking/transportation	95%	99%	94%	98%
Total	**94%**	**88%**	**95%**	**88%**

Table 24 shows the population-weighted results of the demand savings analysis for the full population by sampled building type.

Table 24. Demand Savings Analysis Results by Building Type

	2021				2022			
Building type	PAC summer (kW)	PAC winter (kW)	PGE summer (kW)	PGE winter (kW)	PAC summer (kW)	PAC winter (kW)	PGE summer (kW)	PGE winter (kW)
College/university	145	291	147	338	319	314	316	308
Data center	330	325	331	324	2	2	2	2
Food service	18	20	17	22	14	15	13	14
Hospital/healthcare	130	123	126	126	197	206	194	200

Building type	2021				2022			
	PAC summer (kW)	PAC winter (kW)	PGE summer (kW)	PGE winter (kW)	PAC summer (kW)	PAC winter (kW)	PGE summer (kW)	PGE winter (kW)
K-12 school/education	663	655	654	656	182	188	179	180
Lodging	153	142	147	147	192	328	207	357
Miscellaneous	724	718	689	745	391	408	380	394
Multifamily	1,024	1,683	1,079	1,591	1,178	1,901	1,237	2,106
Office	514	536	510	553	208	233	204	234
Parking/transportation	429	375	406	392	6	5	5	5
Total	**4,130**	**4,870**	**4,107**	**4,894**	**2,687**	**3,601**	**2,738**	**3,800**

4.10 ENERGY USE INTENSITY ANALYSIS

As part of the impact evaluation, the Tetra Tech team attempted to obtain utility billing data from customers to compare the building's overall energy use to target values. We requested at least 12 months of billing data for all fuel types at the facility. The results of the most recent 12 months of utility data, normalized to kBtu-per-square-foot based on project size, were then compared to the median EUI from the ENERGY STAR website.

The Tetra Tech team was able to collect utility billing data for 22 projects as part of the evaluation. After reviewing the data, only ten projects were identified where the data were complete and corresponded with the project. Multiple projects submitted utility data that included additional buildings, which was prevalent for college campuses and large healthcare customers. Additional data difficulties included missing months of data, utility estimated data, and changes to the building operation during the most recent 12-month period.

Table 25 shows the results of the comparisons between median EUI (from ENERGY STAR) and site EUI from the utility bills. The nine projects with a median EUI for comparison achieved an area-weighted average of 49.3 kBtu-per-square-foot, which is 12 percent lower than the area-weighted median EUI of 55.7.

Table 25. Energy Use Intensity Results by Reporting ID

Reporting ID	Market sector	Project type	Project area (sq. ft.)	Median EUI (kBtu/sq. ft.)	Site EUI (kBtu/sq. ft.)	Percentage difference
6	Education	K-12 school/ education	129,000	48.5	82.8	-71%
15	Education	K-12 school/ education	200,046	48.5	49.6	-2%
27	Education	College/ university	55,000	48.5	23.9	51%
30	Education	College/ university	43,913	84.3	29.0	66%
33	Lodging/ residential	Multifamily	54,603	59.6	28.7	52%

Reporting ID	Market sector	Project type	Project area (sq. ft.)	Median EUI (kBtu/sq. ft.)	Site EUI (kBtu/sq. ft.)	Percentage difference
50	Education	College/ university	20,719	84.3	66.8	21%
73	Healthcare	Outpatient	21,468	62.0	59.3	4%
80	Healthcare	Outpatient	104,227	62.0	39.4	36%
101	Office	Office	20,163	52.9	24.5	54%
106	Manufacturing	Food processing	67,657	N/A	41.9	N/A
Total (area-weighted)[16]				**55.7**	**49.3**	**12%**

[16] Area-weighted results exclude Reporting ID 106, which did not have a median EUI for comparison.

APPENDIX A: WHOLE BUILDING SAVINGS REVIEW MEMO

SUMMARY

Rouj Energy Analytics (Rouj Energy) performed a technical review of the methodology used to calculate gas and electricity savings for Whole Building projects of the Energy Trust Trust of Oregon's (Energy Trust) 2021−2022 New Buildings program. The review included the program's Technical Guidelines for the 2019 and 2021 Oregon energy codes and Energy Modeling Summary Workbook. This review aimed to assess the application of the American Society of Heating, Refrigerating and Air Conditioning (ASHRAE) Appendix G guidelines to estimate baseline energy usage and calculate energy savings. In particular, the review focused on identifying areas for improvement or preferred methods for estimating whole-building project energy savings using energy modeling techniques under ASHRAE-based codes.

Three whole-building projects permitted under the 2019 Oregon Energy Code were randomly sampled to assess the application of the methodology and its impacts. The 2019 Oregon Energy Code represented a significant departure from previous codes. Additionally, this review sought to assess whether the technical guidelines follow best industry practices for commercial new construction programs and accurately characterize the baseline energy consumption for estimations of energy savings.

Rouj Energy, as part of the Tetra Tech team, was tasked with this technical review and prepared this memo to describe the methods, present findings and recommendations based on the technical review of the methods, and summarize the potential impact on whole-building project energy savings and realization rates.

REVIEW OF THE TECHNICAL GUIDELINE

Rouj Energy reviewed Energy Trust's 2019 and 2021 Oregon Energy Code Technical Guidelines. 2019 Oregon Energy Code relies on ASHRAE 90.1−2016 Appendix G and 2021 Oregon Energy Code on ASHRAE 90.1−2019 Appendix G. Both versions of ASHRAE 90.1 Appendix G refer to the ASHRAE 90.1−2004's prescriptive requirements for determining the inputs of the baseline model as an effort to keep the baseline stable and minimize the learning curve and potential errors associated with baseline modeling for each code cycle. The new *Energy Simulation Requirements* added to the 2021 Oregon Energy Code Technical Guidelines document is a significant improvement as it provides clarity and direction in terms of specific modeling approaches for common and varied scenarios such as additions, tenant improvements, and buildings served by off-site plant systems.

To adjust the 2004 ASHRAE baseline model to a 2016 ASHRAE or 2019 ASHRAE baseline, ASHRAE refers to a Pacific Northwest National Laboratory (PNNL) study that uses prototype models including several building types to come up with a ratio of energy use intensities (kiloBtus/feet^2) between the two energy codes. However, Energy Trust's Technical Guideline instructs modelers to estimate the ratios at an end-use level extracted from the same prototype models. This step adds more granularity to the analysis and more accurately reflects the consumption change, since different end-uses varied in terms of their consumption decrease from ASHRAE 2004 to the 2016 version.

Developing a baseline model according to the prescriptive requirements of ASHRAE's relevant code cycle (2016 or 2019 ASHRAE) would more accurately reflect the energy consumption of the project if built at the code level prescriptively. However, Rouj Energy believes that the program should continue to employ the ratio-based adjustment of a 2004 ASHARE baseline mainly for two reasons:

- The ratio-based adjustment is dictated by the script of the ASHRAE Appendix G code when the performance-based path to code compliance is taken, and is here to stay, applying to all future ASHRAE code cycles—only the ratios will get updated. Since new construction energy efficiency programs have historically relied on energy code to establish the baseline it is critical not to deviate from the script of the code for consistency. Otherwise, two baseline models need to be created: one for showing code compliance to acquire building permits and sometimes Leadership in Energy and Environmental Design (LEED) certification, and one for the program. Creating a second model is labor-intensive and prone to errors and inconsistencies as a result of switching baselines and the learning curve associated with baselines changing with each code cycle.
- A different set of design/construction strategies works for each path (prescriptive versus performance-based). Many high-profile buildings or buildings with unique design features and limitations, such as historical buildings, have no choice but to take the performance-based code path since they need the trade-offs to accommodate certain design features such as unlimited curtain walls.

Therefore, Rouj Energy believes not only following ASHRAE Appendix G is sufficiently accurate and is a universally accepted methodology in the industry to predict baseline energy consumption, but it is also a more sustainable and practical way to establish the baseline and would encourage more customers to participate in the program.

When there is more than one building type included in a prototype model group—mid-rise multifamily and high-rise multifamily, for example—the end-use ratios are calculated as the averages of the end-use ratios of both building types within the building grouping. Rouj Energy recommends applying the specific, more relevant building type end-use ratios instead of averaging the ratios to better reflect the project's building type and energy profile. For example, in the case of a high-rise multifamily building, using the end-use ratio specific to the high-rise multifamily building type should provide a more accurate basis for the adjustment. Or a primary school may more accurately be adjusted using the ratios related to primary schools instead of the average ratios for primary and secondary schools combined.

The New Buildings Technical Guidelines also require estimating an end-use level ratio for fuel mix (percentage of electric versus gas consumption in kBtu) which adds another level of granularity to the analysis and makes the adjustment more accurate and realistic. This ratio is independent of building type and is estimated using the project's fuel-mix ratio regarding the share of fuel consumption.

REVIEW OF SITE-LEVEL METHODOLOGIES

Rouj Energy performed a technical review of three sampled Whole Building projects (Sites A, B, and C), all permitted under the 2019 energy code to assess the application of the program's savings methodology and its impacts. Rouj Energy investigated whether the ASHRAE Appendix G energy modeling guidelines were followed appropriately to establish baseline performance and estimate energy savings.

Site A

Site A is a new construction, mixed-use high-rise multifamily building with 25 stories and a building area of 421,226 square feet located in ASHRAE Climate Zone 4C. This high-rise is comprised of retail space on the ground floor, 8 floors of commercial offices, and 14 floors of residential units. The energy efficiency measures implemented in Site A include *lighting*, efficient *HVAC systems*, and an *envelope* with efficient glazing and above-code *insulation*.

Lighting system. Strategies (efficient lighting equipment) to lower lighting power density (LPD) for various space types in the proposed model are the main drivers of energy savings associated with the lighting end-use.

Building envelope. Building envelope consists of high-performance curtain wall assemblies on each side, with an average performance U-factor of 0.34 and solar heat gain coefficient (SHGC) of 0.27. Solid wall and roof assemblies are also significantly better than code, with wall assemblies designed for an average of R-20 and roof assemblies designed for an average of R-40 insulation. The baseline model's window-to-wall ratio was reduced to the 40 percent maximum with ASHRAE 90.1−2004 Appendix G performance factors assigned to all assemblies.

HVAC system. The building (office, retail, and residential units) is served by variable refrigerant flow (VRF) heat pumps. Office spaces are zoned as *core* and *shell*, with heat recovery ventilation. A dedicated outdoor air system unit provides ventilation to the office and retail spaces, and directed ducted ventilation is designed for the residential units. While currently unoccupied, the ground floor retail and office space are core-and-shell for future tenant fit-out. However, VRF capacity has been provided for full occupancy with refrigerant branch piping and manifolds provided to all future tenant spaces as reflected in the proposed model.

Review of the Savings Methodology

The methodology to calculate Site A's electric and gas energy savings consists of a traditional energy modeling methodology using eQUEST version 3.65 as the energy modeling software with no extraneous engineering analysis and calculations performed extrinsically to the model. A proposed model and a baseline model following the ASHRAE 90.1−2016 Appendix G guidelines have been created that refer to ASHRAE 90.1−2004 to assign prescriptive parameters and characteristics used as input variables in the model. The energy consumption variance between the baseline and the proposed model result is then adjusted at the end-use level to reflect the energy consumption of an ASHRAE 90.1−2016 prescriptive requirements. This method aligns with Energy Trust's Technical Guidelines to estimate energy savings. All savings came from regulated loads.

Review Findings

Given the function of the site and the types of energy efficiency measures implemented for Site A, Rouj Energy believes that using eQUEST as an energy modeling software is an appropriate tool to estimate the associated electric savings. A few spot checks related to various spaces' LPDs and wall and glazing assemblies' performance factors verified that the correct baseline, ASHRAE 90.1−2016 Appendix G has been employed for this project.

Based on Rouj Energy's review, calculating the end-use ratios using a weighted average of the end-use ratios associated with the various building types (multifamily, office, and retail) within this mixed-use building was an accurate approach. Per our previous comment on the Technical Guidelines, end-use ratios specific to high-rise multifamily buildings could be used instead of the average end-use ratios for high-rise and mid-rise multifamily buildings to increase accuracy. Applying the fuel-mix ratios at the end-use level was consistent with Energy Trust's Technical Guidelines.

Window-to-wall ratio. The building's exterior walls are mostly comprised of curtain walls with the assumed maximum window-to-wall ratio of the baseline model reduced to 40 percent. However, ASHRAE 90.1−2004's prescriptive requirements allow for up to 50 percent window-to-wall ratio. Adjusting the window-to-wall ratio to 50 percent maximum allowable in the baseline model is more representative of the proposed design and should result in increased energy savings.

5.5.4.2 Fenestration Area

5.5.4.2.1 Vertical Fenestration Area. The total *vertical fenestration area* shall be less than 50% of the *gross wall area*.

Site B

Site B is a new 72,824-square-foot, single-story primary school building in ASHRAE Climate Zone 5B. The building houses typical school spaces such as classrooms, offices, circulation areas, conference rooms, electrical and mechanical rooms, a multi-purpose room, a gymnasium, and a kitchen designed for a maximum occupancy of 800 people. The energy efficiency measures implemented in Site B only produced positive gas savings related to the heating system.

The air-side HVAC system is primarily fan coil units with an energy recovery ventilator dedicated to ventilating the classrooms and corridor. The kitchen is served by a dedicated rooftop unit, and the gymnasium and surrounding areas are served by variable-air-volume air handler units. All wall, roof, and glazing areas are modeled identically in the baseline and proposed models, as the building design did not have insulation levels that exceeded code-minimum requirements.

Review of the Savings Methodology

Rouj Energy focused the methodology review on the gas measures and savings only since the total electric energy savings were negative. The methodology to calculate the gas energy savings for Site B is a traditional energy modeling methodology using eQUEST version 3.65 with no extraneous engineering analysis performed extrinsically to the model. Savings came from a single regulated end-use: space heating.

Two energy simulation models were developed for this project: a proposed model and a baseline model following the ASHRAE 90.1−2016 Appendix G guidelines, which refers to ASHRAE 90.1−2004 Appendix G for prescriptive requirements and performance factors. Therefore, the baseline ASHRAE 90.1−2004 prescriptive parameters and characteristics were used as input variables in the baseline model.

The energy consumption difference between the baseline and the proposed models was then adjusted at the end-use level to reflect the energy consumption of an ASHRAE 90.1−2016 compliant model. In this case, a ratio of 0.71 related to space heating end-use type and a ratio of 0.99 related to service water heating for the school building group (average ratios for primary and secondary school types) derived from PNNL prototype models were used to adjust the baseline space heating and service water heating consumption, respectively.

Overall, the savings methodology used for Site B aligns with Energy Trust's Technical Guidelines to estimate energy savings, and no discrepancy was found in the methodology application and baseline assignment.

Review Findings

Based on the energy efficiency measures implemented in Site B, Rouj Energy believes that employing energy simulation modeling using eQUEST as an energy modeling software is an appropriate methodology to estimate the associated energy savings. Also, based on Rouj Energy's review, the baseline adjustment using end-use and fuel-mix ratios for this building type was consistent with Energy Trust's Technical Guidelines. However, Rouj Energy recommends using end-use ratios specific to the primary school building type instead of the average end-use ratios for primary school and secondary school building types to increase accuracy.

Site C

This project is a 95,629-square-foot major renovation, including architectural, mechanical, electrical, and plumbing systems on the west side of a registered historical landmark building. For this reason, the project was limited in terms of envelope upgrades. However, since this building is primarily a laboratory space, the major energy driver is associated with the 100 percent outside air requirement with high circulation rates for the research and teaching laboratory spaces, including the vivarium. The energy savings associated with the mechanical system and heat recovery are the main energy-saving drivers. There are also savings associated with upgrading interior and exterior lighting systems.

The existing heating and cooling loads are served via campus steam and campus chilled water from central plants. Both systems are used in the proposed design as auxiliary systems. Heat-recovery chillers primarily service the heating and cooling loads. The central cooling plant, District Utility Plant (DUP), is being simultaneously updated and is included as a special measure for separate Energy Trust incentives. The new DUP performance is assumed in both the baseline and proposed models for this analysis. The existing efficiency of the central steam plant is assumed for both the baseline and proposed models for this analysis, consistent with ASHRAE−90.1-2016's treatment for district heating and cooling systems.

Review of the Savings Methodology

Only electric energy savings were reported for Site C. The methodology employed to calculate the electric energy savings for Site C includes energy simulation methodology using EDSL Tas software package with various engineering analyses performed to inform the model's input variables. Two energy simulation models were developed for this project: a proposed model and a baseline model following the ASHRAE 90.1-2016 Appendix G guidelines. While EDSL Tas is not a commonly used simulation software, it seems like an appropriate tool to use for a whole-building analysis (comparable to IESVE) with the capability to run hourly (8,760) simulation analysis.

In accordance with the program's Technical Guidelines, end-use ratios based on PNNL's prototype models were used to accurately adjust the baseline to the program's baseline. Savings came from both regulated and unregulated loads. The only unregulated load is for refrigeration end-use, and it relates to cooling energy from the central plant chiller. A ratio of one is considered for this unregulated end-use per the program's guidelines.

A building-level fuel-mix ratio was applied to the total modeled consumption (baseline and proposed) as opposed to applying relevant fuel-mix ratios at the end-use level. This is inconsistent with the program's Technical Guidelines instructing modelers to calculate an end-use-specific fuel-mix ratio, only applicable to *space heating*, *domestic hot water heating*, and *cooling* end-uses where fuel switching is possible. In this case, the baseline model has gas heating and no electric heating. At the building level, baseline energy usage is 31 percent electric and 69 percent gas in Btus. But the proposed model is the reverse: all-electric heating and no gas heating, resulting in energy usage that is 89 percent electric and 11 percent gas at the building level. Applying the fuel-mix ratio to the entire baseline model usage—as opposed to adjusting the baseline space heating to show consumption for the same fuel type as the proposed building—significantly and inappropriately increases the baseline consumption and, therefore, savings. This results in disproportionately high savings, approximately equal to the proposed model’s consumption, which does not seem to be realistic and may significantly lower the realization rate for this project in the impact evaluation.

In addition, the lab building, including research spaces and teaching laboratories, is categorized as *Other* in terms of building type since its energy profile significantly varies from typical college or education facilities. However, the *Other* category might be too generic for the purpose of aligning with the Technical Guideline's methodology of applying the ratios of the specific building type prototype model end-use breakdowns. The *Other* category collapses all types of buildings that fall outside of the specified building types. Labs are unique when it comes to temperature control and ventilation operation. Applying the ratios related to *Outpatient Healthcare* or *Hospital* building type may provide a closer apples-to-apples comparison, given the similarities in load profile, air circulation rates, and outside air requirements.

Based on the project description: "*For estimating the west-side (current project's scope) results, all east-side zones have been removed from a copy of the baseline and proposed energy models of the entire building. In future, the baseline and proposed models of the entire building will be updated for the east-side systems to match the final construction documents. To report the east-side baseline consumption, the west-side baseline model consumption will be subtracted from the whole-building baseline model to ensure that the savings from the west and east side match the final design of the entire building.*" This is a standard approach for phased projects or a new wing on an existing building, and even though the energy savings for this portion of the project might not be accurately reflected, accounting for them by taking the difference in the full model ensures both phases are accurate when taken together.

Review Findings

Overall, the savings methodology used for Site C aligned with Energy Trust's Technical Guidelines to estimate the energy savings following ASHRAE 90.1−2016 Appendix G. But a discrepancy was found in terms of the methodology application and adjusting for the fuel-mix ratio at the end-use level as previously described. However, as part of the impact evaluation, a thorough review of all the modeling parameters and characteristics will be undertaken and verified through project documentation and site data, if needed. Rouj Energy suspects that savings would decrease, and this will result in a less than 100 percent realization rate due to updating the fuel-switch ratio.

To facilitate a detailed review and given the level of complexity of this site and the unconventional ASHRAE interpretation that is needed for a project of this nature, Rouj Energy recommends that the implementer provides a thorough methodology description with references to the final version of the supplementary engineering analyses used for the final models' inputs.

Recommendations

The application of ASHRAE 90.1−2016 Appendix G through the 2004 prescriptive requirements was applied well in all three of these projects; however, the end-use ratios may not have been. Rouj Energy recommends adding a layer of quality assurance to review the ratio application (both end-use and fuel-mix ratios) to catch errors early on as projects go through a learning curve with this new additional step, given the potentially significant impact on energy savings.

When there is more similarity and compatibility between the project type and a building type within a building grouping (e.g., *primary school* in the *school* grouping that also includes *secondary school*), Rouj Energy recommends the Technical Guidelines require applying the end-use ratios from the closest building type to the project instead of applying the averages of the entire building type grouping.

APPENDIX B: SCHEDULING OUTREACH MEMO

This memorandum discusses the interview scheduling outreach difficulties that the evaluation, measurement, and verification (EM&V) team experienced during primary data collection efforts of Energy Trust of Oregon, Inc.'s (Energy Trust) New Buildings program.

INTRODUCTION

Tetra Tech's outreach, associated with scheduling facility operator interviews, was conducted in consultation with Energy Trust and program management contractor (PMC) staff. After the Tetra Tech team conducted project file reviews of sampled projects, we communicated with Energy Trust and PMC staff about which projects were receiving facility operator interviews in the evaluation process. PMC staff handled the initial introductions before the Tetra Tech team began its scheduling outreach. Tetra Tech anticipated that having this initial introduction occur after project files were reviewed would lessen the time between the introduction and the Tetra Tech team calling customers and would increase customer agreement.

The Tetra Tech team attempted to schedule facility operator interviews with 103 project contacts within the sample to discuss the project and current building operations and assess parameters used in the energy analysis. From our experience, the keys to a successful recruitment process are accurate and updated building contact information and consistent, but not intrusive, contacting attempts to complete this task promptly.

The initial recruitment process to schedule facility operator interviews started with the PMC and Tetra Tech's engineers around July 7, 2023, for a portion of 2021 projects. Due to slow response rates and competing priorities, additional staff were brought on board in September 2023 to coordinate all interview contacting. All 103 projects had been contacted by mid-December to schedule a facility operator interview. Forty-six of the 64 interviews completed were conducted by December 31, 2023.

The responsibility for the interview scheduling outreach transitioned to one of Tetra Tech's senior Survey Research Center staff members in late January 2024 to increase the frequency of attempts and to complete the outreach efforts for the remaining projects.

SUMMARY OF DIFFICULTIES

The primary issues experienced when conducting outreach were (1) lack of current project/building contact information, (2) slow response time by building contacts, and (3) unwillingness to schedule an interview due to other priorities. Below are the details associated with each of these primary issues experienced.

Lack of current contact information

Tetra Tech conducted outreach with over 200 individual contacts to schedule interviews for 103 projects within the evaluation sample. Sixty-eight of the 103 projects required new primary contact information to be obtained by PMC staff at least once during the outreach period, with 5 projects requiring new contact information three to five times during the outreach period. The typical time between requesting and receiving new contact information ranged from 5 to more than 15 days; during this wait time, general business telephone numbers and Google searches were used to attempt to identify and reach out to new contacts associated with the project and current building operations.

Slow response time by building contacts

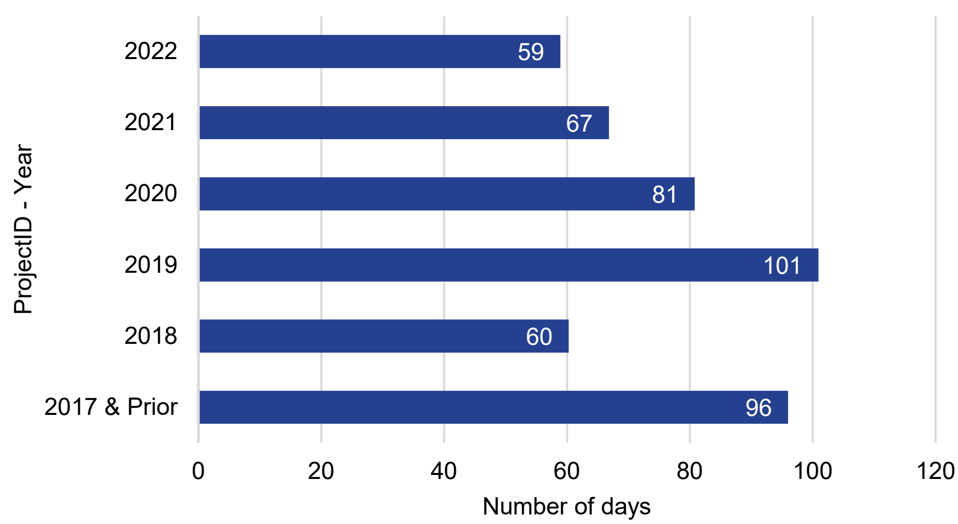
The PMC sent an introductory email to each of the original primary contacts explaining the purpose and reason for the evaluation and interview and introduced Tetra Tech to the contact. Tetra Tech began their scheduling outreach with an email explaining the purpose and details of the interview and how to schedule an interview with Tetra Tech. If no response was received after the first email, a follow-up email was sent, followed by telephone calls, if no response received after the second email. Forty-three interviews were scheduled and conducted by sending these first emails.

The average number of emails sent by Tetra Tech per project to schedule an interview was three. When necessary, emails were followed by telephone calls. The average number of calls made by Tetra Tech per project to schedule an interview was 4, with 21 projects receiving 5 or more calls totaling 123 calls.

The overall average number of days to complete[17] was 78.7 days. The average number of days for program year (PY) 2021 (PY2021) projects was 89.8 days, while the PY2022 average number of days to complete was 66.5 days. The difference in program years is notable, as having a participant in the latter program year shortened the average participation time by almost a month.

Figure 1 shows the impact on the average number of days to complete due to the time between when projects began participating in the New Buildings program (ProjectID-Reference Year) and the Program Year (2021 or 2022) the incentive was provided.

Figure 1. Average Number of Days to Complete



The individual 2017 average number of days to complete was 113 days. The sample size for all prior years was too small to show separately, and it was combined with 2017.

The average number of days to complete may also have been impacted by the business sector that it serves. Many business sectors are experiencing economic impacts due to inflation, high interest rates, skilled workforce storage, and high material costs, which may impact the availability of contacts to schedule an interview with Tetra Tech. Table 26 summarizes—by business sector—the number of projects that required 91 days or more to get to a *completed* status and the resulting number of interviews actually completed with the scheduling outreach lasting 91 days or more.

[17] Complete represents one of the following: an interview was conducted, the customer refused to schedule an interview, or other actions were taken by Tetra Tech due to the inability to schedule an interview with the customer.

Table 26. 91+ Days to Complete Interview by Sector

Business sector	2021 91−180 days	2021 181−270 days	Total 2021 91+ days projects	2021 91−180 days interviews completed	2021 181−270 days interviews completed	Total 2021 91+ days projects interviews completed	2022 91−180 days	2022 181−270 days	Total 2022 91+ days projects	2022 91−180 days interviews completed	Total 2022 91+ days projects interviews completed	Total projects	Total interviews completed
College/ university	1	0	**1**	0	0	**0**	0	0	**0**	0	**0**	**1**	0
Data center	0	0	**0**	0	0	**0**	0	0	**0**	0	**0**	**0**	0
Food sales	2	0	**2**	0	0	**0**	0	0	**0**	0	**0**	**2**	0
Food service	5	0	**5**	1	0	**1**	1	0	**1**	1	**1**	**6**	2
Hospital/ healthcare	1	3	**4**	0	1	**1**	2	1	**3**	0	**0**	**7**	1
K-12 school/ education	1	0	**1**	0	0	**0**	1	0	**1**	0	**0**	**2**	0
Lodging	2	0	**2**	1	0	**1**	1	0	**1**	1	**1**	**3**	2
Manufacturing/ food processing	0	0	**0**	0	0	**0**	1	0	**1**	0	**0**	**1**	0
Mercantile	0	0	**0**	0	0	**0**	1	0	**1**	0	**0**	**1**	0
Multifamily	2	2	**4**	1	1	**2**	4	0	**4**	3	**3**	**8**	5
Office	1	0	**1**	0	0	**0**	0	0	**0**	0	**0**	**1**	0
Parking/ transportation	0	1	**1**	0	0	**0**	0	0	**0**	0	**0**	**1**	0
Public safety	0	0	**0**	0	0	**0**	1	0	**1**	1	**1**	**1**	1
Service	1	1	**2**	1	1	**2**	1	0	**1**	1	**1**	**3**	3
Warehouse	0	0	**0**	0	0	**0**	1	0	**1**	0	**0**	**1**	0
Total	16	7	**23**	4	3	**7**	14	1	**15**	7	**7**	**38**	**14**

Unwillingness to schedule an interview

The lack of current contact information resulted in additional time-consuming efforts to determine who should be contacted. Oftentimes, even when the primary contact information was accurate, interviews were unable to be scheduled due to competing priorities of the contacts, limited staffing, or simple unwillingness to participate. Eleven project contacts refused to schedule an interview with Tetra Tech for similar reasons.

Additionally, it was not uncommon, when new contact information was provided, that the new contact indicated they had little to no awareness of the project and that the person with the necessary project awareness was no longer with the company. Therefore, they did not want to schedule an interview or provide any additional details about the project.

Even with the difficulties described above, Tetra Tech conducted interviews for 64 of 103[18] projects included in the Energy Trust's New Buildings program sample.

[18] Overall number of interviews completed does not include all of the Whole Building or Path to Net Zero projects, some of which followed a different process for contacting and scheduling through Rouj Energy.

APPENDIX C: MEASURE CATEGORY MAPPING

This section presents the measure mapping for *evaluation description* to measure categories used in reporting.

Table 27. Measure Category Mapping

Measure category	Evaluation description
Appliance	Clothes dryer
Appliance	Clothes washer
Appliance	Dishwasher
Appliance	Icemaker
Appliance	Refrigerator
Custom	Custom fan
Custom	Custom gas measure
Custom	Custom HVAC
Custom	Custom insulation
Custom	Custom lighting
Custom	Custom lighting control
Custom	Custom other measure
Custom	Custom process
Custom	Custom pump
Custom	Custom refrigeration
Custom	Custom transformer
Custom	Other measure
Domestic hot water	Domestic hot water measures
Domestic hot water	Faucet aerator
Domestic hot water	Showerhead
Domestic hot water	Tanked water heater
Domestic hot water	Tankless water heater

Measure category	Evaluation description
Envelope	Air sealing
Food equipment	Food equipment
HVAC	Boiler
HVAC	Ductless heat pump
HVAC	Gas furnace
HVAC	Heat pump
HVAC	HVAC
HVAC	Radiant heating
HVAC	Server closet mini-split AC units
HVAC	Variable refrigerant flow
HVAC	Ventilation
Lighting	Lighting
Lighting	Lighting controls
Non-savings	Commissioning
Non-savings	Other renewables fee
Non-savings	Promotion
Non-savings	Study
Whole building	Leadership in Energy and Environmental Design
Whole building	Market Solutions Offering

APPENDIX D: DETAILED PROJECT RESULTS

This section presents the results of the selected projects by program year, building code, sampled building type, and anonymized reporting ID.

Table 28. Project Results by Program Year, Building Code, Sampled Building Type, and Anonymized Reporting ID

Reporting ID	Track	Year	Code	Building type	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
1	Path To Net Zero	2021	2019	College/university	19,648	789	20,059	715	102%	91%
2	System-Based	2022	2014	College/university	35,164	0	36,121	0	103%	N/A
3	System-Based	2021	2014	Lodging	0	1,139	0	1,139	N/A	100%
4	System-Based	2021	2014	Hospital/healthcare	121,543	0	106,299	0	87%	N/A
5	System-Based	2021	2014	Lodging	74,842	3,492	67,359	3,492	90%	100%
6	Whole Building	2021	2014	K-12 school/education	117,624	23,219	44,611	21,876	38%	94%
7	System-Based	2021	2014	Hospital/healthcare	14,533	117	7,370	73	51%	63%
8	System-Based	2021	2014	Lodging	158,808	6,075	130,290	4,134	82%	68%
9	Whole Building	2022	2014	Service	373,993	2,922	374,304	921	100%	32%
10	Whole Building	2021	2014	Office	169,736	8,417	165,078	6,571	97%	78%
11	Whole Building	2021	2014	Hospital/healthcare	248,327	0	292,382	0	118%	N/A
12	Market Solutions	2021	2014	Multifamily	250,654	6,987	217,493	6,993	87%	100%
13	Market Solutions	2021	2014	Multifamily	195,636	6,657	132,271	6,651	68%	100%
14	Path To Net Zero	2021	2014	K-12 school/education	1,155,617	11,734	1,155,617	8,373	100%	71%
15	Whole Building	2022	2014	K-12 school/education	573,308	15,808	604,787	9,232	105%	58%
16	System-Based	2021	2014	K-12 school/education	0	5,308	0	5,308	N/A	100%
17	System-Based	2021	2014	Hospital/healthcare	219,625	3,808	179,286	3,535	82%	93%
18	Path To Net Zero	2021	2014	Office	336,967	27,952	354,396	26,568	105%	95%
19	System-Based	2021	2014	Parking/transportation	2,098,178	0	2,097,829	0	100%	N/A
20	System-Based	2021	2014	Parking/transportation	109,835	0	113,516	0	103%	N/A
21	System-Based	2021	2014	Parking/transportation	112,262	0	120,098	0	107%	N/A

Reporting ID	Track	Year	Code	Building type	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
22	Path To Net Zero	2022	2014	Office	350,042	0	367,248	0	105%	N/A
23	Path To Net Zero	2021	2014	K-12 school/education	200,085	13,863	188,286	13,025	94%	94%
24	System-Based	2021	2019	K-12 school/education	28,291	2,013	28,584	2,013	101%	100%
25	System-Based	2022	2019	K-12 school/education	0	1,139	0	1,138	N/A	100%
26	System-Based	2022	2019	K-12 school/education	11,491	675	10,782	675	94%	100%
27	Path To Net Zero	2021	2014	College/university	667,233	0	694,499	0	104%	N/A
28	Whole Building	2021	2014	College/university	98,464	0	98,580	0	100%	N/A
29	Whole Building	2022	2014	Public safety	126,127	9,207	117,913	7,700	93%	84%
30	System-Based	2022	2014	College/university	108,577	3,092	96,061	2,606	88%	84%
31	Whole Building	2022	2014	K-12 school/education	103,482	10,906	101,660	10,537	98%	97%
32	System-Based	2021	2014	Service	47,409	0	58,223	0	123%	N/A
33	Market Solutions	2021	2019	Multifamily	217,078	5,222	115,459	1,431	53%	27%
34	Whole Building	2022	2014	Hospital/healthcare	784,498	20,800	784,498	12,870	100%	62%
35	System-Based	2022	2019	K-12 school/education	0	16,183	0	9,161	N/A	57%
36	System-Based	2021	2014	College/university	294,899	552	188,949	545	64%	99%
37	System-Based	2021	2014	Service	72,304	5,248	73,345	4,476	101%	85%
38	System-Based	2021	2014	Office	7,656	0	7,358	0	96%	N/A
39	System-Based	2021	2014	Parking/transportation	115,932	0	105,164	0	91%	N/A
40	System-Based	2021	2014	Hospital/healthcare	81,781	0	49,583	0	61%	N/A
41	Market Solutions	2022	2014	Multifamily	82,256	5,125	51,641	5,033	63%	98%
42	Market Solutions	2021	2019	Multifamily	44,366	1,348	14,463	1,078	33%	80%
43	System-Based	2022	2019	Warehouse	27,447	0	0	0	0%	N/A
44	Market Solutions	2021	2014	Multifamily	92,848	5,227	92,850	5,227	100%	100%
45	System-Based	2021	2019	Food Sales	99,846	5,772	101,915	5,772	102%	100%
46	Market Solutions	2021	2019	Multifamily	263,993	3,261	84,331	2,644	32%	81%

Reporting ID	Track	Year	Code	Building type	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
47	Market Solutions	2022	2019	Multifamily	128,061	4,445	123,586	4,860	97%	109%
48	Market Solutions	2022	2019	Multifamily	321,101	0	264,403	0	82%	N/A
49	System-Based	2021	2014	Lodging	0	1,319	0	1,319	N/A	100%
50	System-Based	2021	2019	College/university	5,349	680	2,478	680	46%	100%
51	Market Solutions	2021	2014	Multifamily	34,087	3,096	33,947	3,103	100%	100%
52	System-Based	2022	2019	Hospital/healthcare	145,997	1,908	45,348	1,905	31%	100%
53	System-Based	2021	2019	Parking/transportation	125,919	0	127,588	0	101%	N/A
54	Market Solutions	2021	2014	Multifamily	202,698	7,519	202,698	9,666	100%	129%
55	System-Based	2021	2019	Hospital/healthcare	0	167	0	167	N/A	100%
56	System-Based	2021	2014	Lodging	66,211	3,804	66,174	3,730	100%	98%
57	Market Solutions	2022	2021	Multifamily	91,933	0	67,920	0	74%	N/A
58	Whole Building	2022	2019	K-12 school/education	0	19,379	0	19,608	N/A	101%
59	Market Solutions	2022	2014	Multifamily	210,416	4,343	240,875	5,025	114%	116%
60	Market Solutions	2021	2014	Multifamily	7,798	1,789	7,798	887	100%	50%
61	System-Based	2021	2014	Lodging	18,885	1,583	22,109	1,591	117%	101%
62	Market Solutions	2022	2014	Multifamily	205,200	4,700	179,004	4,385	87%	93%
63	Market Solutions	2021	2014	Multifamily	643,125	14,753	598,939	11,298	93%	77%
64	Market Solutions	2021	2014	Multifamily	389,306	5,553	400,605	6,987	103%	126%
65	Market Solutions	2022	2019	Multifamily	57,724	679	32,206	774	56%	114%
66	System-Based	2022	2019	Parking/transportation	17,527	3,262	18,373	3,123	105%	96%
67	System-Based	2021	2019	Food service	4,670	978	4,539	978	97%	100%
68	System-Based	2022	2019	Lodging	21,905	2,779	0	0	0%	0%
69	Data Center	2021	2019	Data center	671,796	0	671,796	0	100%	N/A
70	System-Based	2021	2019	Office	10,864	0	10,598	0	98%	N/A
71	System-Based	2022	2019	Hospital/healthcare	26,019	7,094	14,791	5,878	57%	83%

Reporting ID	Track	Year	Code	Building type	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
72	Market Solutions	2022	2019	Lodging	383,973	2,931	198,987	3,943	52%	135%
73	System-Based	2021	2019	Hospital/healthcare	17,571	0	15,242	0	87%	N/A
74	Market Solutions	2022	2019	Lodging	390,641	4,155	290,052	4,876	74%	117%
75	System-Based	2021	2014	Parking/transportation	262,863	0	188,988	0	72%	N/A
76	System-Based	2022	2019	Mercantile	40,064	1,853	43,505	862	109%	47%
77	System-Based	2021	2019	Hospital/healthcare	73,955	0	73,758	0	100%	N/A
78	System-Based	2022	2019	Hospital/healthcare	4,097	238	3,664	214	89%	90%
79	Market Solutions	2021	2019	Food service	1,555	4,327	1,555	4,327	100%	100%
80	System-Based	2022	2019	Hospital/healthcare	51,041	2,439	59,645	1,256	117%	51%
81	Market Solutions	2021	2019	Food service	4,679	764	4,679	979	100%	128%
82	System-Based	2021	2019	Manufacturing/food processing	26,803	1,758	27,241	1,758	102%	100%
83	Market Solutions	2021	2014	Lodging	46,184	2,548	46,127	2,548	100%	100%
84	System-Based	2022	2019	Hospital/healthcare	13,414	553	9,486	558	71%	101%
85	Market Solutions	2021	2019	Food service	4,679	764	4,679	827	100%	108%
86	System-Based	2021	2019	Food sales	0	862	0	862	N/A	100%
87	System-Based	2022	2019	Mercantile	302,429	9,001	358,852	8,697	119%	97%
88	System-Based	2022	2021	Parking/transportation	20,778	2,880	9,938	2,880	48%	100%
89	System-Based	2022	2021	Food service	11,172	44	11,468	44	103%	100%
90	System-Based	2022	2021	Manufacturing/food processing	22,592	278	13,081	279	58%	100%
91	System-Based	2021	2021	Food service	0	1,293	0	1,293	N/A	100%
92	System-Based	2022	2021	Manufacturing/food processing	600	703	540	633	90%	90%
93	System-Based	2022	2019	Food service	12,709	3,449	0	0	0%	0%
94	System-Based	2021	2019	Food service	3,240	431	3,240	431	100%	100%
95	System-Based	2022	2021	Office	33,628	0	31,072	0	92%	N/A

Reporting ID	Track	Year	Code	Building type	Ex-ante kWh	Ex-ante therms	Ex-post kWh	Ex-post therms	kWh RR	Therms RR
96	Data Center	2022	2019	Data center	8,132	0	10,508	0	129%	N/A
97	System-Based	2022	2021	Hospital/healthcare	5,131	0	5,154	0	100%	N/A
98	Data Center	2022	2019	Data center	5,878	0	5,878	0	100%	N/A
99	System-Based	2022	2021	Lodging	0	431	0	431	N/A	100%
100	System-Based	2022	2021	Office	5,701	0	4,231	0	74%	N/A
101	System-Based	2022	2021	Office	4,047	0	3,968	0	98%	N/A
102	System-Based	2022	2021	Service	51,199	0	41,695	0	81%	N/A
103	System-Based	2022	2021	Food sales	17,210	255	8,230	450	48%	177%
104	System-Based	2022	2021	Office	8,579	0	8,886	0	104%	N/A
105	System-Based	2022	2021	Food service	851	431	851	431	100%	100%
106	System-Based	2022	2021	Manufacturing/food processing	65,145	0	78,213	0	120%	N/A
107	System-Based	2022	2021	Food service	0	431	0	431	N/A	100%
108	System-Based	2022	2021	Mercantile	8,563	0	8,220	0	96%	N/A
109	System-Based	2022	2021	Food service	0	1,293	0	1,293	N/A	100%
110	System-Based	2022	2021	Food service	0	862	0	862	N/A	100%
Total					**15,628,095**	**368,863**	**14,357,963**	**318,645**	**92%**	**86%**

APPENDIX E: DETAILED FINDINGS AND RECOMMENDATIONS FOR MODELKIT PROJECTS

This section presents the detailed findings and recommendations by measure type for the Market Solutions Offerings projects that used ModelKit as the basis of savings. Table 29 below shows the modeled *lighting* findings and recommendations in further detail, while Table 30 shows findings and recommendations by measure.

Table 29. Market Solutions—Multifamily Modeled Projects—Modeled Lighting Findings and Recommendations

Issue	Projects affected	Findings	Recommendations
Exterior lighting savings in the model	7 out of 7 mid-/ high-rise projects	Even though exterior savings were not selected for these projects in the project workbook and no documentation was provided for *exterior lighting*, savings were claimed for all mid-/high-rise building projects reviewed.	Review *exterior lighting* end-use ratios and ModelKit/EnergyPlus parameter translation to ensure no exterior lighting savings are claimed when the measure is not selected.
Interior in-unit lighting savings in the model when the measure was not selected	4 out of 4 mid-/ high-rise projects where *LPD reduction in living units* was not selected	Even though *interior lighting s*avings were not selected in the project workbook and no documentation was provided for *interior lighting*, savings were claimed for four mid-/ high-rise building projects.	Review *interior lighting* end-use ratios and ModelKit/EnergyPlus parameter translation to ensure no *interior lighting* savings are claimed when the measure is not selected.
Corridor lighting savings in the model	7 out of 7 mid- /high-rise projects	Even though corridor LPD savings were not approved for multifamily Market Solutions projects, they were claimed for all reviewed mid-/high-rise building projects.	Add *corridor lighting* to approved measures in the measure approval document (MAD) prior to including them in the models.
		Two projects were given prescriptive corridor savings in the evaluation, as there was sufficient documentation provided.	Collect and provide documentation on *corridor lighting*, including lighting plans showing all portions of the building that are not the same and lighting specification sheets for all lighting present in the corridors. Showing the reported LPD calculation in a workbook calculator would also enhance clarity.
		Two projects provided partial *corridor lighting* documentation, which was insufficient to receive prescriptive evaluated savings.	
		Three projects provided no *corridor lighting* documentation.	

Table 30. Market Solutions—Multifamily Modeled Projects—Measure-Specific Findings and Recommendations

Measure	Projects with adjustments	Findings	Recommendations
Faucet aerators	9 out of 9	The translation of code and installed gallons per minute (GPM) into the EnergyPlus model was unclear, so savings were recalculated from the prescriptive path from Minnesota TRM.	*Faucet aerators* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
		Some apartments were found to have units with multiple bathroom faucets, which were not included in the savings model.	Enhance documentation of the quantities of faucets in apartments with multiple bathroom faucets.
Air tightness	0 out of 1	None.	None.
Clothes washer	3 out of 3	The translation of code and installed energy consumption (kilowatt-hours) into the EnergyPlus model (W/sq. ft.) was unclear, so savings were recalculated from the per-unit savings estimates from the ENERGY STAR® simulation guidelines.	*Clothes washers* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
		Some apartments were found to only have clothes washers in a subset of units, which were not captured in the savings model.	Enhance documentation of clothes washer quantities in apartments where only some units have washers.
Condensing tank water heater	3 out of 5	The installed efficiency was adjusted in the final design model to match the ENERGY STAR certificate for three projects.	Enhance quality assurance/quality control (QA/QC) of the thermal efficiency of the water heater in the final design model.
Condensing high-efficiency furnace	0 out of 1	None.	None.

Measure	Projects with adjustments	Findings	Recommendations
Ductless heat pump (DHP) in living units	3 out of 3	Two projects had adjustments to baseline and final design cooling and heating efficiencies because the efficiencies in the EnergyPlus model did not match those specified in the application or documentation.	Ensure desired efficiencies are correctly translated through ModelKit. Enhance QA/QC on baseline efficiencies to ensure alignment with the International Energy Conservation Code (IECC) 2018 or the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 Appendix G guidelines.
		One project selected the *DHP* measure but only modeled the building's energy recovery ventilator (ERV) system in the final design.	In buildings with multiple HVAC systems, provide an explanation or rationale for the system input into the final design model.
Dishwasher	5 out of 5	The translation of code and installed energy consumption (kilowatt-hours) into the EnergyPlus model (W/sq. ft.) was unclear, so savings were recalculated using per-unit savings estimates from the ENERGY STAR certificates.	*Dishwashers* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
Dryers	2 out of 2	The translation of code and installed energy consumption (kilowatt-hours) into the EnergyPlus model (W/sq. ft.) was unclear, so savings were recalculated using the deemed savings values from MAD 231.2.	*Dryers* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
		Some apartments were found to only have clothes dryers in a subset of units, which were not captured in the savings model.	Enhance documentation of the quantities of clothes dryers in apartments where only some units have clothes dryers.

Measure	Projects with adjustments	Findings	Recommendations
Efficient exhaust fans	8 out of 8	The translation of code and installed energy consumption (kilowatt-hours) into the EnergyPlus model (fan module) was unclear, so savings were recalculated using the deemed savings values from MAD 269.1 for six projects.	*Exhaust fans* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
		One project had no documentation related to the exhaust fans provided.	Provide documentation on *exhaust fans*, including their airflow rate (cubic feet/minute (cfm)), energy efficiency (W/cfm), any settings (high and low speeds), and whether the fans run continuously.
		One project had no documentation supporting the fact that the exhaust fans run continuously.	
Energy recovery ventilation—in model	1 out of 2	One project had adjustments in ERV type and effectiveness in the EnergyPlus model to match the mechanical schedule.	Enhance QA/QC of model inputs to ensure they are consistent with project documentation.
Exterior lighting power reduction	1 out of 1	The translation of code and installed *exterior lighting* (kilowatt-hours) into the EnergyPlus model (design level Watts) was unclear, so savings were recalculated using the prescribed savings methodology.	*Exterior lighting* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
Heat pump water heater	1 out of 1	For the one project where *heat pump water heaters* were selected in the application and shown to have been installed in the building, the EnergyPlus final design file did not appear to model savings correctly, as the *WaterHeater:HeatPump* field was not utilized.	Review ModelKit/EnergyPlus parameter translation to ensure that *heat pump water heaters* are being modeled correctly.

Measure	Projects with adjustments	Findings	Recommendations
High-efficiency split system	2 out of 2	One project had adjustments to baseline and final design cooling and heating efficiencies, as the efficiencies in the EnergyPlus model did not match the desired efficiencies specified in the application or documentation.	Ensure that the desired efficiencies are correctly translated through ModelKit. Enhance QA/QC on baseline efficiencies to ensure they align with IECC 2018 or ASHRAE 90.1 Appendix G guidelines.
		One project did not capture the fact that the apartments were cooled by a combination of the building's ERV system and room air conditioning units.	In buildings with multiple HVAC systems, provide an explanation or rationale of what system is input into the final design model.
High-performance windows	3 out of 8	The installed solar heat-gain coefficient (SHGC) and U-value were adjusted in the final design model to match the documentation provided for the two projects.	Enhance QA/QC of the window specifications in the final design model to ensure they match the building documentation.
		No documentation was provided for the *high-performance windows* for one project, so the savings were removed from the model.	Obtain documentation showing SHGC and U-value of installed windows before including them in the energy model.
LPD reduction in living units	5 out of 5	The installed *LPD* was adjusted in the final design model to match the documentation provided for five projects.	Enhance QA/QC of the *LPD* used in the final design model to ensure they match the building documentation.
		Two of the five projects did not provide documentation showing the *LPD* calculation, including in-unit lighting plans and lighting specification sheets.	Collect in-unit lighting plans and specification sheets to support *LPD* used in the final design.
		Two of the five projects selected one specific unit size (e.g., studio) as representative for the entire building, with one project utilizing the prescriptive lighting calculation and the other project performing a calculation on a PDF directly.	Adjust the unit *LPD* calculation to include the quantities, areas, and lighting present in the building's different unit types. This will eliminate the potential errors caused by selecting a "typical" apartment that is not representative of the building.
		One project used the *LPD* reported on the ComCheck report directly.	Gather lighting plan and specification sheet documentation rather than depending on ComCheck results, which may not reflect the latest changes in building design.

Measure	Projects with adjustments	Findings	Recommendations
Packaged terminal heat pump (in-unit)	3 out of 3	Three projects had adjustments to baseline and final design cooling and heating efficiencies, as the efficiencies in the provided EnergyPlus model did not match the desired efficiencies specified in the application or documentation.	Ensure that the desired efficiencies are correctly translated through ModelKit. Enhance QA/QC on baseline efficiencies to ensure they align with IECC 2018 or ASHRAE 90.1 Appendix G guidelines. In instances where multiple unit sizes are present within the building, explain how the varying efficiencies are weighted or reflected in the final design energy model.
Refrigerator	7 out of 7	The translation of code and installed energy consumption (kilowatt-hours) into the EnergyPlus model (W/sq. ft.) was unclear, so savings were recalculated from the per unit savings estimates from the ENERGY STAR certificates.	*Refrigerators* should not be included in the EnergyPlus model and should be calculated via a prescriptive path to increase the savings accuracy for the measure.
Roof insulation	0 out of 3	None.	None.
Tankless water heater	2 out of 2	The translation of code and installed energy consumption (therms) into the EnergyPlus model (*WaterHeater:Mixed module*) was unclear, so savings were recalculated using the deemed savings values from MAD 72.2 for both projects.	Ensure that the desired efficiencies are correctly translated through ModelKit, or alternately, pull *tankless water heaters* out of the EnergyPlus model and calculate via a prescriptive path.
Wall insulation	9 out of 9	The baseline R-value was not modeled according to IECC 2018 code requirements in the two low-rise buildings.	Enhance QA/QC on baseline efficiencies to ensure they align with IECC 2018 for low-rise multifamily buildings.
		The final design R-value was adjusted in seven projects to achieve the desired final R-value specified in the documentation.	Ensure that the desired insulation values are correctly translated through ModelKit to the final EnergyPlus energy model.
		Two projects did not provide sufficient documentation to support the installed *wall insulation*, so savings were removed from the project.	Gather and provide documentation showing the R-value before inputting it into the energy model.

Measure	Projects with adjustments	Findings	Recommendations
Window-to-wall ratio	4 out of 4	*Window-to-wall ratio* savings were claimed for four mid-/ high-rise multifamily buildings even though according to ASHRAE 90.1 Appendix G, baseline and final design window-to-wall ratios should be set equal if the building type is not listed in Table G3.1.1-1. *Multifamily* is not listed in the table, so savings associated with this measure were removed from the model.	Remove the *window-to-wall ratio* as an approved measure from MAD 258.