Making and Saving Energy on the Path to Net Zero:
Best Practices and Tools for Affordable Multifamily Housing

Energy Trust of Oregon Net Zero Fellowship Report

Pacific Crest Affordable Housing, LLC

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Net Zero Fellowship Research Team

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Table of Contents

1. Executive Summary

This research aimed to develop and share best practices for the development of affordable multifamily housing from Pacific Crest Affordable Housing's model, with takeaways relevant to market-rate housing developers and the Pacific Northwest building industry at large.

Pacific Crest Affordable Housing (PCAH) is a developer of affordable multifamily housing based in Bend, Oregon with a reputation for building highly sustainable projects. From 2006 to 2022, Pacific Crest developed eight low-rise affordable apartment properties providing 331 apartments for low-income households earning 60% Area Median Income and below. The first five of these properties exclusively serve senior households and three of the properties serve workforce and family households. The four newest PCAH projects each received Earth Advantage Platinum certification—Earth Advantage's highest level of recognition.

Pacific Crest's approach includes long-standing relationships with their architect, contractor and primary subtrades, providing consistency across projects that enables learning through each development cycle. This learning process applied to its approach to sustainability. Utilizing financial incentives for energy efficiency and renewable energy systems, Pacific Crest integrated progressively more impactful sustainability measures in each project.

To guide project decision-making and maximize the value of its investments in energy performance, Pacific Crest developed a financial model that assessed the long-term financial impact of energy efficiency measures (EEMs) and renewable energy systems. This spreadsheet gave Pacific Crest a tool to evaluate which EEMs and renewables provided the most value, helping it earn financial support for larger investments in energy efficiency and renewable energy based on the projected payback on investment through energy cost savings. PCAH's analysis supported its project design including central heating, cooling, ventilation and hot water systems and the inclusion of all utilities in the affordable rents. It also led Pacific Crest to prioritize solar PV at the start of a project, as opposed to later in the design process.

In the first year after opening each project, Pacific Crest began to review solar production data and utility statements to evaluate energy performance. Particularly with its newest projects, it eventually gathered enough data to conclude that the buildings were demonstrating significantly higher energy use than expected. Pacific Crest reviewed energy modeling, utility bills and solar PV data to get a handle on the scope of the issue. Confident from their solar PV monitoring data that the solar PV system was working as designed, Pacific Crest wanted to understand whether the difference between their projects' predicted and actual energy performance was attributable to inaccurate pre-construction energy modeling estimates, underperforming energy efficiency measures or both. Ultimately, this path of inquiry led Pacific Crest to Energy Trust of Oregon's Net Zero Fellowship and resulted in this report.

Research Goals

The research team's activities were guided by three primary research goals:

1) **Understand the difference between pre-construction energy performance estimates and actual energy performance.**

2) **Evaluate which energy efficiency and renewable energy systems were the best long-term investments for the three Pacific Crest projects.**

3) **Develop guidance and resources for others seeking to evaluate the impacts of energy efficiency measures and renewable energy systems over the lifespan of their projects.**

Research Methods

With support from Energy Trust of Oregon, the Pacific Crest research team assessed the energy performance of three Pacific Crest projects: Canal Commons One and Azimuth 315, both located in Bend, Oregon serving workforce and family households, and IronHorse Lodge, a Senior (55-and-older) property located in Prineville, Oregon. Pacific Crest hired an energy consultant who followed a calibrating modeling approach to evaluate their pre-construction energy models and create a new understanding of building energy performance based on available measurable data. The calibrated energy model results were inputted, along with updated cost information, into Pacific Crest's financial model to create revised financial projections, allowing Pacific Crest to assess whether the projects' energy efficiency measures and renewable energy systems still provided good long-term investments.

This process also offered an opportunity for the research team to gather lessons, insights and resources for others to approach evaluation of energy investments. Based on Pacific Crest's original financial model spreadsheet, the team created a "Make It & Save It" Template to support developers in their understanding of the costs and benefits of various sustainability measures over the life cycle of a building. This Template was evaluated through a peer review process and submitted to Energy Trust of Oregon to be published along with this report.

Summary of Key Research Findings and Recommendations:

- While project energy use was higher than expected, Pacific Crest's investments in energy efficiency measures and renewable energy are likely having a significant impact on reducing building energy usage and utility costs.

- Submetering system issues—expired software licenses, configuration errors and reporting lapses due to connectivity disruptions—prevented the team from gaining enough useful data to provide further clarity around the specific end uses driving energy use. Based on observations, the energy drivers likely include windows being left open, more items plugged into outlets, increased appliance use, and the buildings generally being used extensively; however, future research prioritizing submetering could provide additional insight and potential confirmation.

- The process of updating Pacific Crest's financial model demonstrated the importance of accurate energy and financial information for assessing investments in EEMs and renewables. Specific recommendations include:
  - Facilitate open communication between developers, contractors and energy modelers about the intended purpose of the information and specific parameters of measures and costs being evaluated.
  - Energy modelers should pay close attention to occupant-driven assumptions that are hard to predict yet have significant impact on energy usage. For example, evaluate whether higher temperature setpoints, higher plug load usage or windows being left open have a strong impact on the EEM decisions.
  - As part of the final bid process facilitated by the general contractor, or "Bid Day," explore having subcontractors submit estimates for both baseline (code minimum) and proposed measure costs to improve the incremental cost figures used in the evaluation EEMs and renewables.
  - Pay close attention to utility rates since they can have a large impact on payback periods and long-term value of investments in EEMs and renewables, and both rates and metering policies can change over time.

- Efforts should be made to identify and focus on those measures that provide clear value and how to implement them at scale, not to spend excessive time and money splitting hairs on each measure and system when the value is marginal.

- Optimizing building design is an iterative process where learning happens each development cycle that can be applied to the next project. Ensuring a good process and applying those lessons to the next development will lead to better value.

2. Introduction

Pacific Crest Affordable Housing

Pacific Crest Affordable Housing (PCAH) is an affordable housing developer based in Bend, Oregon. Over the course of 18 years, beginning in 2006, Pacific Crest developed eight new affordable properties, all located in Central Oregon, using a patchwork of federal, state and local funding sources. The properties serve households earning 60% Area Median Income (AMI) and must remain affordable through the duration of a 60-year affordability period in Oregon. While Pacific Crest's primary business is developing new buildings, it stays involved as the owner after development is completed and engages a property management company to operate the buildings.

As a long-term owner, PCAH was interested in the benefits of energy savings over a longer timeline. Sustainability is a central pillar of PCAH's development model. Each of its eight completed affordable multifamily projects features progressively more impactful sustainability features, earning Pacific Crest a reputation for pushing the envelope of sustainability in affordable multifamily housing. This commitment to sustainability went beyond building design to include raised bed gardens, rainwater irrigation, lavender farming, beekeeping and honey production.

Pacific Crest's approach to energy performance evolved over the course of its eight projects to feature whole building envelope upgrades, ductless variable refrigerant flow heating and cooling systems with energy recovery ventilators, LED lighting with controls, solar thermal hot water, ENERGY STAR appliances and large solar PV systems. Since 2010, Pacific Crest's projects are master metered (e.g., meters covering tenant and common area usage together) with net metering. Including all utilities in the affordable rents provided residents with monthly cost certainty while protecting against rising costs of energy and allowed the renewable energy savings to be captured directly in the bills. Each of the last four properties was certified Earth Advantage Platinum. (See Appendix A: Project Summaries)

Pacific Crest's Financial Model

As a for-profit company and steward of public funds, Pacific Crest sought to justify spending on sustainability and maximize value for the money spent. To that end, Pacific Crest developed a spreadsheet template between 2012 and 2015 to evaluate the long-term monetary value of investments in energy efficiency and renewable energy and help guide decision-making. Pacific Crest's financial model performed the following primary calculations:

- **<u>Life Cycle Cost Analysis (LCCA):</u>** Life Cycle Cost Analysis is a method of assessing the total cost of a project or ownership of an entity. It is useful when evaluating different project alternatives to maximize financial performance. The LCCA provided a "break-even" point in number of years using estimates of first cost, annual energy cost and various other financial factors.

- **<u>Net Present Value (NPV):</u>** Net Present Value is the difference between the present value of cash inflows (benefits) and the present value of cash outflows (detriments) over a set period. NPV is used to assess an investment's likely profitability. Pacific Crest's financial model performed 20-, 30- and 40-year Net Present Value calculations.

- **<u>Making vs. Saving Comparison:</u>** The spreadsheet calculated the total cost per kWh of all EEMs and all renewable energy systems to compare investments in each. The cost per kWh calculation divided the first cost, or initial investment, by the estimated annual kWh energy savings or production, showing results both with and without financial incentives.

NPVs of Energy Savings
OR Code Minimum vs. IronHorse 1
Original (Pre-Construction) Version

Assumptions		Comments
Energy Savings [kWh/SF/Yr]	9.2	Compared to OR Code Min Multifamily Bldg
Energy Cost Inflation Adjuster [%/Yr]	3.25%	CAGR - Oregon Retail Rate 2003 - 2014
Energy Cost 1st Yr [$/kWh]	0.137	Pacific Power OR Sch 28 (No Facilities Charge)
Gross Building Square Footage [SF]	27,540	IHL Actual GBSF
Discount Rate [%/Yr]	4.00%	Market Driven (WACC - Cost of Capital)
EEMs* 1st Costs w/o Incentives[$]	261,630	Data Assembled for ETO-PTNZ (Qualifying Costs)
EEMs Incentive Amount	119,639	Data Assembled for ETO-PTNZ & After Tax
EEMs 1st Costs w /Incentives	141,991	Calculated Intermediate Result
Renewables** 1st Costs w/o Incentives [$]	271,417	Actuals (64.09 kW PV & 12 Panel Thermal)
Renewables Incentive Amount [$]	212,667	Market Driven & After Tax
Renewables 1st Costs w/ Incentives [$]	58,750	Calculated Intermediate Result
Toatl 1st Costs [$] w/o Incentives [$]	533,047	Calculated Final Result
Total 1st Costs [$] w/ Incentives [$]	200,741	Calculated Final Result

* EEMs = Energy Efficiency Measures (Save It)
** Renewables = Solar PV & Thermal (Make It)
* ETO-PTNZ = Energy Trust of Oregon Path to Net Zero

Color Code
Assumptions Inputs & Results
Calculated
Actuals or Pro Forma
Results

Other Inputs Energy Usage/SF/Yr & /Yr/Bldg	Conversion kBTUs-->KWh kBTU/SF/Yr	kWh/SF/Yr	kWh/Yr/Bldg
OR Code Minimum Bldg (OCM)*	41.0	12.0	330,918
IronHorse Lodge 1 Bldg (IHL)**	9.6	2.8	77,483
Energy Savings IHL vs OCM	31.4	9.2	253,435

* Typical OCM Multifamily EUI of 41.0 Provided By Energy Trust of Oregon
** PTNZ Goal Based on Model-Projected IHL Multifamily EUI of 9.6 Energy Trust of Oregon

Conversion 1 kBTU --> kWhs
0.29307107

Detriments (-) & Benefits (+) Flow*	0	1	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	(200,741)	34,642	39,370	40,650	46,197	63,609	87,583	120,592
Cumulative Detriments & Benefits [$]	(200,741)	(166,099)	(15,899)	24,751	200,997	754,147	1,515,776	2,564,459
Break-Even [#Yrs]				B/E				

* w/ Incentives 1st Costs Only (No Operating or Replacement Costs)

NPVs of Detriments & Benefits Flow (D&BF)	
20-Yr Net Present Value [$] D&BF	405,511
30-Yr Net Present Value [$] D&BF	673,812
40-Yr Net Present Value [$] D&BF	923,381
Break-Even [# Yrs]	6

Save vs. Make $/kWh	Save or Make kWh/Yr	w/o Incentives [$] 1st Cost	$/kWh	w/ Incentives 1st Cost	$/kWh
Save It*	130,681	$ 261,630	**$ 2.00**	$ 141,991	**$ 1.09**
Make It**	122,754	$ 271,417	**$ 2.21**	$ 58,750	**$ 0.48**
Combo	253,435	$ 533,047	**$ 2.10**	$ 200,741	**$ 0.79**

* "Save Its" include all Energy Efficiency Measures (EEMs)
** "Make Its" include Solar PV and Solar Thermal (Renewables)

Pacific Crest's financial model with Life Cycle Cost Analysis, NPVs and Save vs. Make comparison for IronHorse Lodge, a 26-unit Senior affordable apartment property located in Prineville, Oregon.

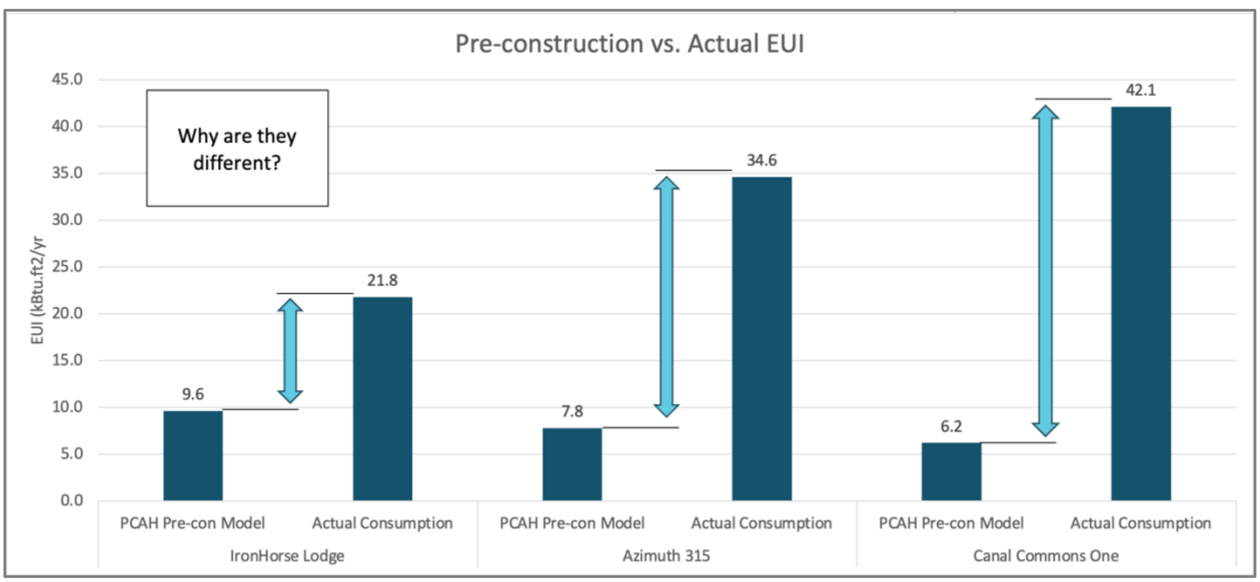
Pacific Crest sought enough information to determine which options represented clear value and then move forward. As a rule of thumb, if a measure or project only achieved 80% of the benefits projected by the spreadsheet and still represented good value, then Pacific Crest was comfortable moving forward. This rule of thumb enabled Pacific Crest to feel confident with the spreadsheet as a tool and navigate the inherent uncertainty of dealing with long-term projections.

The spreadsheet analysis helped Pacific Crest justify and earn financial support for larger investments in whole-building efficiency and renewable energy. For its newer projects, the financial modeling results indicated that renewable energy systems could be more cost effective than energy efficiency measures when financial incentives were included, leading Pacific Crest to prioritize solar PV at the outset of a project and fully utilize renewable energy incentives.

Predicted vs. Actual Energy Performance

After each property opened, however, Pacific Crest gradually became aware from review of utility statements that energy consumption was higher than pre-construction estimates. Moreover, the gap between the predicted and actual energy use increased with its newer projects. To understand the issue, Pacific Crest began to revisit their original projections and ask questions within their network of industry contacts, focusing primarily on three projects: Canal Commons One, Azimuth 315 and IronHorse Lodge.

Chart A: Estimated vs. Actual Energy Use



This path of inquiry ultimately led to Pacific Crest embarking on a Net Zero Fellowship research grant supported by Energy Trust of Oregon.

Pacific Crest's Net Zero Fellowship research focused on three properties:

Canal Commons One (completed 2020)

Canal Commons One is a 48-unit apartment property in Bend, OR providing 1-, 2- and 3-bedroom apartments for workforce & family households earning 60% Area Median Income and below.

Azimuth 315 (completed 2019)

Azimuth 315 is a 50-unit apartment property in Bend, OR providing 1- and 2-bedroom apartments for workforce & family households earning 60% Area Median Income and below.

IronHorse Lodge (completed 2016)

IronHorse Lodge is a 26-unit apartment property in Prineville, OR providing 1- and 2-bedroom apartments for Seniors (55+) earning 60% Area Median Income and below.

3. Research Goals & Methods

Research Goals

The Net Zero Fellowship team pursued their research with a goal of producing lessons, insights and resources that advance the development of Net Zero affordable housing and contribute to the greater commercial building industry in the Pacific Northwest. The research was guided by several main questions aligned with underlying research goals, including subsequent questions that emerged through the research process.

1) **Understand the difference between pre-construction energy performance estimates and actual energy performance.**

    "How well did Pacific Crest's pre-construction energy performance modeling predict actual energy performance?"

2) **Determine which energy efficiency and renewable energy investments provided the most value at the three properties.**

    "Which design strategies and technologies provide the most 'bang for the buck' in terms of cost per kWh savings and the most beneficial payback?"

3) **Develop guidance and resources for others seeking to evaluate the impacts of energy efficiency measures and renewable energy systems over the lifespan of their projects.**

    "How well did Pacific Crest's financial model work as a tool to assess the long-term value of investments in energy efficiency measures and renewable energy systems?"

    "What knowledge does a developer need to conduct this type of analysis?"

    "How does a developer obtain 'good enough' energy and cost information during the development process to make useful predictions and guide decision-making?"

Research Methods

Activity #1: Calibrated Modeling

Pacific Crest contracted with Greg Collins, Principal at Zero Envy, to perform an energy analysis of the three properties through a process of calibrated modeling.

Calibrated modeling is a process used to refine building energy models by comparing predicted energy use to actual measured data. This process involves adjusting input parameters in the model until the simulated energy consumption closely matches the real-world energy bills. Calibrated modeling aims to enhance the accuracy of energy models, making them more reliable tools for predicting building performance and evaluating the impact of energy efficiency measures.

For this project, the Net Zero Fellowship research team wanted to use calibrated modeling to help understand why actual consumption was so different from design phase estimates, and to validate the energy savings from selected EEMs to make sure they were still a good investment.

The original energy models for the three projects were done by different people using different software tools several years ago. The reports and incentive program spreadsheets were available, but the original models were not available to calibrate, and a new model was constructed from the ground up for this research project utilizing current software tools. Since developing energy models and then calibrating them is such a time-intensive process, and because the projects are similar in their designs, the research team chose to perform a detailed calibration exercise on one of the three projects and use those findings to extrapolate the savings to the other two. The Canal Commons One project had utility data, solar production data, an electricity submetering system and energy monitoring within the HVAC system, so that project was chosen for the detailed study.

Zero Envy built the model of Canal Commons One using "as-built" construction plans and additional measure and system details from the OHCS-MEP program and Earth Advantage certification materials and gathered available energy performance data—monthly electric and gas utility bills, solar PV monitoring data, VRF energy metering data and observations from the on-site management and maintenance staff—to use in the calibration process. They then updated the model's assumptions and inputs until the energy performance of the model closely aligned with actual performance data. (See Appendix B: Calibrated Modeling)

Activity #2: Updated Financial Models

After the calibrating modeling process was completed, the research team's next step was to update the financial models to evaluate whether the savings still warranted the initial investment. Through this process, the research team simultaneously sought to assess the strengths and limitations of the financial model as a decision-making tool.

The research team used available post-construction project costs and incentive amounts, with updated project utility rates based on the last 12 months of natural gas and electric statements, to add to the revised energy estimates in the updated financial models. The renewable energy system costs were consistent with their pre-construction contracts, so the only project costs needing to be updated were the incremental EEM costs.

The research team gathered detailed budget and change order information from Pacific Crest's project records, with assistance from their general contractor, to revise the incremental costs for the EEMs. Many of the available cost figures within the project budgets, invoices and change order tracking logs, however, did not specifically break out the costs associated with energy improvements. When specific EEM costs were broken out, the team noticed that they varied widely from the original baseline and estimated costs for several EEMs in Pacific Crest's original financial analysis, raising questions about the original methodology.

In some cases, Pacific Crest was able to identify or reverse engineer the method used originally to estimate costs, typically by cost per unit or cost per square footage, and trace inaccuracies in the original cost estimates to incorrect square footages or unit counts from the early design phase. In those instances, Pacific Crest used the original methodology to update the baseline cost estimates with the correct square footages and unit counts. In other cases, Pacific Crest worked with their general contractor and subcontractors to get "best guess" estimates for the baseline as well as the cost of specific efficiency improvements from within budget line-items. The team documented where this took place in their research materials with an explanation of the process and adjustment. During this step in the process, the research team also tested RSMeans as a potential resource for developers to use to estimate costs and cross-reference existing figures.

Once the updated information was compiled, the Pacific Crest research team entered this information, along with the revised baseline energy consumption and EEM energy savings estimates, into the financial model. The model produced a revised Life Cycle Cost Analysis, NPV calculations and Make It & Save It comparisons, along with a ranking of energy efficiency measures and renewable energy systems on an individual cost per kWh basis.

Research Activity #3: Resident Listening Session

Pacific Crest held a resident listening session at Azimuth 315 to learn from resident perspectives and provide an opportunity for feedback on the various measures and systems. The meeting was attended by residents, the building's architect, an Energy Trust representative and members of the research team. This semi-structured conversation provided residents with an opportunity to voice questions, learn about the design and function of the building's systems and provide feedback. Pacific Crest documented the questions and feedback and incorporated this input into the research. (See Appendix D: Resident Listening Session Summary)

4. Research Findings

Question #1: How well did Pacific Crest's pre-construction energy performance modeling predict actual energy performance?

All (energy) models are "wrong."

The renewable energy systems are performing largely as designed. Solar PV production estimates were obtained using PVWatts and the systems at all three properties have produced in alignment with the PVWatts estimates.

The original solar thermal energy savings estimates came from calculations performed by our subcontractor. The calibrated modeling combined the solar thermal and condensing hot water systems and showed slightly increased savings, which could be partly attributable to the more efficient water heater.

The energy estimates that Pacific Crest used to conduct their pre-construction financial model analysis primarily came from energy modeling obtained through participation in energy incentive programs. The IronHorse Lodge spreadsheet used EEM savings from modeling created for an ODOE Energy Incentive Program grant. The financial models for Azimuth 315 and Canal Commons used energy modeling created for the Oregon Multifamily Energy Program. Each energy model was created to meet program criteria and provided individual per-measure savings estimates that Pacific Crest applied to assess the estimated value of individual EEMs and the total value of their investments in energy efficiency.

None of the models had a baseline energy estimate that came close to the findings of the calibrated modeling. The process of developing and fine-tuning the calibrated energy model strongly indicated that the baseline energy consumption estimates used in the original modeling for all three projects needed to be much higher.

In some cases, this was due to the lack of a clear baseline estimate. IronHorse Lodge had two versions of energy modeling with notably different baseline energy estimates and Pacific Crest needed to decide how to proceed. The energy modeling for Azimuth 315 did not show a baseline energy usage estimate. To obtain a baseline energy estimate for the Azimuth 315 analysis, Pacific Crest sought guidance from industry connections and used "Oregon Code Minimum" baseline EUIs from Zero Code, and then calculated a baseline annual energy usage from that EUI figure. Canal Commons One had the most complete modeling of the three projects, but its baseline also turned out to be substantially lower than the calibrated modeling results.

The research team concluded that the higher energy use at Pacific Crest's projects is most likely due to a combination of factors:

- Increased use by occupants: It is very likely that the building is simply being used more than generic multifamily building modeling assumptions assume.
    - More occupants in each apartment will use more energy for laundry, hot water, lights and plug loads (TVs, mobile devices, computers, etc.) which would be reflected in the utility bills.
- Increased heating energy: The increase in electricity consumption during heating months seems to implicate the heating system.
    - This could be related to higher temperature setpoints or windows being left open during the winter.
    - It could also be related to building and system issues like reduced heating efficiency due to any number of mechanical issues. There was no evidence discovered of mechanical issues, but it cannot be fully ruled out.
    - While the research team was unable to confirm these during the study period due to HVAC monitoring system outages, it is likely a combination of both. Pacific Crest plans to get better measured data over the upcoming winter to be able to confirm.

There was no evidence that Energy Efficiency Measures have construction flaws or experienced mechanical issues, although this could not be completely eliminated as a possibility.

Prior to this research, Pacific Crest largely took energy modeling results at face value when applying them to their financial model. Through conversations with Zero Envy and other industry connections, it became clear that "valid" energy models can produce very different outcomes depending on the model's assumptions and approach. The qualifications and experience of the energy modeler, the intended purpose for the model and the tools used to perform energy modeling, plus real constraints of cost and time, can all impact the quality of modeling results.

Question #2: Which design strategies and technologies provide the most "bang for the buck" in terms of cost per kWh saved or produced and the payback over the life-cycle duration of the multifamily project?

It was cheaper for the projects to make energy than to save energy.

Pacific Crest's financial model evaluated the individual EEMs and renewables for the three projects on a cost-per-kWh basis, using incremental first costs and estimated energy saved or made. Energy savings in Therms was converted to kWh to be included in this analysis. This first comparison did not include incentives in the total first cost of the EEMs or solar PV systems. It should be noted that measures representing the best investments will vary from project to project, and over time, and the results from this analysis are only for this project.

From the updated energy analysis, the top performing measures (based on payback) are:

- Low-wattage interior & exterior LED lighting: Both interior and exterior lighting performed well. This includes a mix of high-efficiency fixtures but also smart design (most useful light per watt).
- Reduced infiltration: All three projects feature thermal breaks and a high-heel truss design, reducing envelope penetrations, as part of the reduced infiltration measures. This measure provided significant value driving energy savings in the calibrated modeling. It was modeled at 3.5 ACH50, but blower-door testing showed even better results of 2.44 ACH50.
- Solar thermal & condensing hot water: This system demonstrated improved energy savings over the original estimates. Some additional savings may be attributable to the calibrated model combining the high-efficiency gas boiler and solar thermal together, as well as higher natural gas use in total.
- VRF with ERV system: Not the lowest-hanging fruit, but the investment pays back during the expected life of the equipment. Another benefit of the VRF system is that it consolidates outdoor units to give you more roof space availability for solar PV (compared with individual split system heat pumps).

The envelope insulation measures did not show up as well in this analysis, possibly due to the relative efficiency of the baseline code minimum values. For future analysis, it may make sense to study smaller upgrades (e.g., add 2" of rigid wall insulation instead of double-stud walls). The window measure in this analysis may also warrant follow-up based on low modeled savings and "best guess" incremental costs that resulted in a notably high cost per kWh saved.

Table A: Cost per kWh Measure Ranking, Without Incentives

Canal Commons One

Rank	Measure Name	Cost per kWh Saved/Made
1	Interior lighting (0.58 --> 0.38 W/ft2)	$0.29
2	Reduced infiltration (6.5 --> 3.5 ACH50)	$0.50
3	Exterior lighting (5.1 --> 1.7 kW)	$0.90
4	Condensing water heater + solar thermal	$1.05
5	Attic Insulation (R38 --> R80)	$1.75
6	Solar PV	$1.78
7	HVAC: PTHP --> VRF w/ ERV	$1.98
8	Exterior walls (U-0.064 --> 0.035)	$3.03
9	Doors (U-0.7 --> 0.5)	$4.23
10	Windows (U-0.35/S-0.40 --> U-0.29/S-0.21)	$17.82
11	ENERGY STAR Appliances	$20.31

Azimuth 315

Rank	Measure Name	Cost per kWh Saved/Made
1	Reduced infiltration (6.5 --> 3.5 ACH50)	$0.22
2	Condensing water heater + solar thermal	$0.68
3	HVAC: PTHP --> VRF w/ ERV	$0.87
4	Interior lighting (0.58 --> 0.39 W/ft2)	$1.27
5	Exterior lighting (5.1 --> 1.7 kW)	$1.30
6	Attic Insulation (R38 --> R60)	$1.88
7	Solar PV 107.52 kW	$2.51
8	Exterior walls (U-0.064 --> 0.035)	$3.07
9	Doors (U-0.7 --> 0.44)	$5.44
10	ENERGY STAR Appliances	$12.10
11	Windows (U-0.35/S-0.40 --> U-0.25/S-0.21)	$14.91

IronHorse Lodge

Rank	Measure Name	Cost per kWh Saved/Made
1	Windows (U-0.35/S-0.40 --> U-0.25/S-0.25)	-$6.39
2	Reduced infiltration (6.5 --> 3.5 ACH50)	$0.19
3	Doors (U-0.7 --> 0.44)	$0.56
4	HVAC: PTHP --> VRF w/ ERV	$0.95
5	Exterior walls (U-0.064 --> ICF)	$1.09
6	Exterior lighting (5.1 --> 1.7 kW)	$1.12
7	Condensing water heater + solar thermal	$1.24
8	Attic Insulation (R38 --> R60)	$1.56
9	Interior lighting (0.58 --> 0.39 W/ft2)	$1.98
10	Solar PV	$2.05
11	ENERGY STAR Appliances	$12.72

The financial model also compared total renewable energy production and total energy savings, on a first incremental cost-per-kWh basis, with incentives. Once incentives were factored into the analysis, the solar PV systems performed at or near the top in terms of the cost per kWh saved or made.

Table B.1: Canal Commons One - Save vs. Make Comparison, With Incentives

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	610,674	$ 937,937	$ 1.54	$ 628,313	$ 1.03
Make It	181,633	$ 322,910	$ 1.78	$ 72,761	$ 0.40
Combo	792,307	$1,260,847	$ 1.59	$ 701,074	$ 0.88

*Includes solar thermal & DHW savings converted from Therms to kWh

Table B.2: Azimuth 315 - Save vs. Make Comparison, With Incentives

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	634,365	$ 632,891	$ 1.00	$ 424,280	$ 0.67
Make It	153,748	$ 386,581	$ 2.51	$ 3,853	$ 0.03
Combo	788,113	$1,019,472	$ 1.29	$ 428,133	$ 0.54

*Includes solar thermal & DHW savings converted from Therms to kWh

Table B.3: IronHorse Lodge - Save vs. Make Comparison, With Incentives

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	374,894	$ 311,759	$ 0.83	$ 144,211	$ 0.38
Make It	93,525	$ 192,153	$ 2.05	$ 8,697	$ 0.09
Combo	468,419	$ 503,912	$ 1.08	$ 152,908	$ 0.33

*Includes solar thermal & DHW savings converted from Therms to kWh

Pacific Crest's ability to layer loans, grants and tax incentives for renewable energy made it less expensive, on the whole, to produce energy than to save energy from its standpoint as a developer. This outcome validated Pacific Crest's decision to prioritize solar PV from the start of project development.

The research team noted that the financial model assumes a 1:1 net meter credit ratio. Possible changes to net metering no longer crediting energy sent to the grid at the same value per kWh would affect the total financial benefit of the solar PV systems. At the same time, solar PV provides a hedge against other changes in utility arrangements: onsite renewable electricity protects against rising electric rates and increases in value as electric utility rates rise, and enables the property to add battery storage in the future to provide resilience.

Overall, the solar PV systems at all three properties performed in line with the pre-construction PVWatts estimates:

Table C: Predicted vs. Actual Solar Production (2023)

Project	PVWatts Estimated Annual kWh	Measured Annual kWh
IronHorse Lodge	95,254	93,525
Azimuth 315	145,246	153,748
Canal Commons One	213,211	181,033*

*** A partial solar PV system outage occurred at Canal Commons One during 2023. Across 2021-2022, the Canal Commons One PV system averaged 216,900 annual kWh production.**

That is not to say that the solar PV systems performed perfectly; however, when an outage or issue occurred, the PV systems provided alerts typically enabling Pacific Crest's solar contractor to respond quickly. The one notable exception—a months-long partial outage of the solar array at Canal Commons One—took as long as it did to repair because the solar company was being sold and new ownership needed to take over before the repair was completed. In contrast, most EEMs require someone paying attention to notice or uncover issues before they can be fixed.

Beyond cost per kWh analysis, Pacific Crest considered factors such as resilience, reliability and resident feedback in developing recommendations for specific energy efficiency measures and systems. Overall, residents were satisfied with the LED lighting, as well as design efforts to improve natural daylighting, and the supply of hot water from the solar thermal and condensing hot water system. The VRF heating and cooling system satisfied most residents but requires some education and adjustment since it operates differently from traditional HVAC systems and performs most efficiently when temperature settings and controls are not manually adjusted. One resident expressed they would like to have an electric space heater for additional warmth, which is not allowed under the property lease.

Resilience emerged as a subject of resident interest after multiple years dealing with wildfire smoke, as well as a January 2024 VRF system outage at Azimuth 315 that occurred during a winter storm and impacted the whole building. In future projects, Pacific Crest would weigh the efficiency of the VRF system with its higher cost, the requirement for specialized maintenance and potential for whole-building impacts. Pacific Crest was fortunate during the January storm to have the original contractor available and ready to come out to repair the system on a weekend, enabling residents to remain in their apartments overnight. With all HVAC systems, implementing a higher level of air filtration during wildfire season could potentially add cost and reduce mechanical efficiency but be the "best" investment from a health, comfort and safety standpoint. Resident engagement on this topic showed that health and safety concerns, while not mutually exclusive with efforts to reduce energy use, rightly take priority. (See Appendix D: Resident Listening Session Summary)

Question 3: How well did Pacific Crest's financial model work as a tool to assess the long-term value of investments in energy efficiency measures and renewable energy systems?

The key to useful predictions is "good enough" information.

Using the energy savings estimates produced through the calibrated modeling process, the updated financial models indicated that the investments in renewable energy and energy efficiency are providing value. The original energy savings estimates for energy efficiency measures hold up, despite the jump in actual building energy usage, given the research's conclusion that they are helping to reduce total energy use from a higher baseline and still having a positive impact on the bottom line.

It is difficult to make highly accurate long-term predictions for projects with longer timelines, based on the number of unknowns. The question for developers becomes how to obtain information that is “good enough” to make useful long-term predictions and guide decision-making, often while operating within cost and time constraints. Suggestions for improving energy and cost information for the financial model’s analysis are listed in the recommendations below.

In practice, Pacific Crest considered the financial model one source of information and did not need the outputs to be perfect to move forward with decisions. Pacific Crest employed a rule of thumb that when a set of energy investments still showed clear value at 80% of the projected payback provided by the financial model, it was likely “good enough” to move forward. This buffer provided an acceptable margin of error and also led Pacific Crest to prioritize the measures and systems that were “clear winners” and not spend energy examining small marginal gains.

The research team noted that the original spreadsheet’s Life Cycle Cost Analysis did not incorporate equipment maintenance and replacement costs. These costs would impact the Net Present Value outputs, particularly at longer timelines of 30 and 40 years, somewhat lowering the return on investment. Since Pacific Crest’s three projects each demonstrated break-even timelines of less than 10 years, the research team concluded that equipment lifespans and replacement costs would not have greatly affected the viability of the investments. From a decision-making standpoint, Pacific Crest’s “80%” rule of thumb also accommodates, to some extent, additional costs and uncertainty that may not be considered in the analysis. These costs were noted by the research team as an area for future improvement.

5. Recommendations

This is a list of recommendations derived from this research.

Recommendations for project design:

- Every project is different, and it is essential to apply a good process to get the best bang for the buck. In this sense, ensuring a good process (while not the underlying goal) is an important objective on its own.

- Optimizing value is an iterative process where new learning happens over each development cycle and takeaways are applied to future projects. The cost and time constraints of conducting exhaustive energy modeling for each unique project make this especially true. The Make It & Save It Template produced as part of this research is intended to support an iterative approach.

- Open communication across a trusted team of collaborators—including the architect, contractor, solar contractor, engineers and energy modeler—and consistency amongst team members over multiple projects support a process of iterative learning and improvements.

- Efforts should be made to identify and focus on those measures that provide clear value and how to implement them at scale, not to spend excessive time and money splitting hairs on each measure and system when the value is marginal.

- Consider factors impacting solar PV from the outset of a project, particularly if utilizing renewable energy incentives, by prioritizing solar access in site selection, building orientation and available area for solar panels as part of the initial building design.

- The individual measures will vary from project to project and over time. One approach suggested by this research is starting with solar PV as the benchmark measure—determine the payback or $/kWh-saved for that first—and then identify other EEMs that are better or equal.

- Resilience, comfort and health are important considerations on top of efficiency and payback.

- Post-construction verification activities, such as commissioning and blower-door testing, help ensure successful construction outcomes and buildings performing as designed.

Recommendations for obtaining better energy modeling and incremental cost estimates:

- When engaging an energy consultant, developers should ask questions about qualifications, methods and tools (e.g., software) and being transparent about how you plan to use the information provided. There are different approaches with different strengths and weaknesses, and a modeler should be able to speak to the pros and cons. Developers can seek to improve their knowledge of energy modeling to be educated consumers and ask better questions. Proactive communication increases the likelihood of obtaining useful modeling results.

- Energy modelers should consider using more conservative assumptions in pre-construction energy models that assume more usage of the building and systems by occupants (assuming future buildings will have similar tenant mix). Could also use the model to do a sensitivity analysis to verify EEM savings are still good with high or low occupancy assumptions.
    - Plug loads: 0.75 W/ft² (instead of 0.5)

- More accurate cost estimates could be acquired during "Bid Day" through a process coordinated by the general contractor, where baseline measure costs are quoted by subcontractors as a requirement along with the as-designed measure costs.

- More integrated work between energy modeler and cost estimator can ensure costs and energy estimates for EEMs are aligned, and both are using the same baseline and measure assumptions.

Recommendations for specific measures:

- If providing operable windows, consider adding an interlock that turns off the HVAC if it's open, and monitor open periods.

- The solar thermal hot water system performed well for these projects and provided good value on the investment; however, if considering switching to electric heat pumps for water heating, it may be more cost effective to use roof area for additional solar PV instead of adding an extra system for hot water preheat.

- Consider resiliency trade-offs of centralized vs. decentralized systems in terms of impacts when a system goes down.

- Higher-rated air filters during wildfire season can add cost and potentially reduce mechanical efficiency but provide health, comfort and safety benefits.

- Systems that communicate and provide alerts when they are not working provide a great benefit and help support optimal building function.

Recommendations for building operators:

- Ensure that energy monitoring systems remain working. Possible solutions include purchasing a longer subscription at the start of the service, having a 5- or 10-year warranty on the system or an annual service contract from the installing contractor.

- Operations and oversight after the building is opened are critical so systems operate as designed and maintain optimum efficiency. Identifying issues and responding quickly are necessary to keep performance optimized.

- Multifamily properties that are master metered may consider having tenants pay their own utility bills to increase awareness and incentive to reduce energy consumption. Alternatively, consider monitoring energy usage per apartment and providing feedback, or implementing a building-wide energy challenge or other reward system to encourage tenants to reduce energy use.

Recommendations for further research:

- Further research should prioritize submetering to gain further insight into the sources of higher energy consumption. The properties' submetering systems were nonoperational or experienced reliability issues preventing further insight during the research period.

- Future analysis should evaluate the feasibility of adding battery storage to existing solar PV systems at Pacific Crest's properties, which can support resilience and reduce peak energy demand.

6. Make It & Save It Template

Template Development

Based on guidance from Energy Trust, the research team focused on adapting Pacific Crest's original spreadsheet to a user-friendly format, keeping core inputs and outputs fundamentally intact, while adding necessary notes and recommendations. The Make It & Save It Template serves both as a representation of Pacific Crest's analysis, as documented in this case study, and a resource for those interested in a similar approach.

The original Pacific Crest financial model was designed to help analyze the long-term value of energy-saving and energy-making investments with multifamily projects. In doing this, Pacific Crest's intention was to get enough information to determine which options represented value and then move forward. As a rule of thumb, if a measure (or set of measures) still provided a value if it achieved 80% of the estimated performance, then it was likely a safe choice. This rule of thumb enabled Pacific Crest to navigate the inherent uncertainty of long-term projections.

The research team identified multiple opportunities for increasing the Template's functionality through the peer review process. In particular, the team looked at incorporating equipment lifespans and maintenance and replacement costs into the Life Cycle Cost Analysis. Due to the scope and timeline of the research, this and other opportunities were not added to the Template but are listed below as opportunities for future additions.

Summary of Inputs

Project Information	
Property Name	Canal Commons One
Total Building Square Footage (sf)	44,916
Cost of Energy	
Electric Utility Rate ($/kWh)	$0.114
Net Meter Credit Ratio Adjuster (%)	100%
Natural Gas Utility Rate ($/Therm)	$1.199
Annual Energy Usage & Production	
Code Minimum Building Electricity (kWh)	948,284
Proposed Electricity Usage (kWh)	268,196
Code Minimum Building Natural Gas (Therms)	10,833
Proposed Natural Gas Usage (Therms)	7,003
Estimated Renewable Energy (kWh)	181,633
Estimated Renewable Energy (Therms)	0
Project Costs	
Incremental Costs of EEMs ($)	$937,937
Renewable Energy System Costs ($)	$322,910
Financial Incentives	
Energy Efficiency Incentives Total ($)	$309,624
Renewable Energy Incentives Total ($)	$250,149
Financial Assumptions	
Energy Cost Inflation Adjuster [%/Yr]	3.25%
Discount Rate [%/Yr]	4.00%

Model Outputs

Template Version 10/15/24

Net Annual Benefit		
Total kWh Saved (kWh)	498,455	$56,824
Total Therms Saved (Therms)	3,830	$4,592
Total kWh Offset (kWh)	181,633	$20,706
Net Annual Benefit (first year)		**$82,122**

Energy Use Intensity (EUI)			
Typical Multifamily Building*		52.0	kBTU/sf/year
Oregon Code Minimum (OCM)*		41.0	kBTU/sf/year
Canal Commons One	**Net EUI**	36.0	kBTU/sf/year

*Typical MF EUI and OCM EUI from Energy Trust of Oregon Path to Net Zero

Color Code
User inputs
Auto-filled from worksheets
Calculated results
Default assumptions

Life-Cycle Cost Analysis* (Net Detriments and Benefits Flow)	# Years										
	0	1	2	3	4	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	**-$701,074**	$82,122	$84,791	$87,547	$90,392	$93,330	$96,363	$109,514	$150,790	$207,622	$285,873
Cumulative Detriments & Benefits [$]	-$701,074	-$618,952	-$534,161	-$446,614	-$356,222	-$262,892	-$166,529	$251,276	$1,562,562	$3,368,065	$5,854,050
Break-Even [#Yrs]											

*Does not include maintenance, operating, and/or replacement costs

NPVs of Life-Cycle Cost Analysis	
20-Yr Net Present Value [$]	**$744,755**
30-Yr Net Present Value [$]	**$1,380,785**
40-Yr Net Present Value [$]	**$1,972,407**
Break-Even [# Yrs]	**8**

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	**610,674**	**$ 937,937**	**$ 1.54**	**$ 628,313**	**$ 1.03**
Make It	**181,633**	**$ 322,910**	**$ 1.78**	**$ 72,761**	**$ 0.40**
Combo	**792,307**	**$ 1,260,847**	**$ 1.59**	**$ 701,074**	**$ 0.88**

*Includes solar thermal & DHW savings converted from Therms to kWh

The main Output Dashboard tab of the Make It & Save It Template, based on Pacific Crest's original financial model spreadsheet.

Opportunities for Future Additions to the Template

1) Incorporate maintenance and replacement costs into the Life Cycle Cost Analysis. The team discussed methodologies for calculating or estimating maintenance and replacement costs but ultimately decided that we were not certain we could do this effectively within the research timeline.
2) Add the ability to separate resident and common area utilities for calculating the Net Annual Benefit. Owners who do not pay resident utilities would get a more accurate reflection of the value of utility savings for owners who only pay for common area utilities.
    a. This might be "worked around" by separately inputting energy savings and consumption information for common areas and residential apartments, or doing two separate analyses. This will require coordination with the energy modeler to break out the energy savings in this way. Those who use this "workaround" will also need to pay attention to utility rates since common areas and residential areas have different types of meters.
3) Add the capacity to account for demand charges, as well as time-of-use pricing, in the analysis to improve accuracy of the estimated utility costs for the Net Annual Benefit calculation and the evaluation of the EEMs and renewable energy systems.
4) Add the ability to automatically estimate incentive amounts for major incentive programs based on user inputs (energy savings, number of units, etc.), following program rules for determining incentive values.
5) Apply energy efficiency incentives to individual EEMs, enabling an EEM ranking with the real costs per kWh. The team has not fully explored the feasibility of this, but it seems possible to do based on dollar per kWh saved formulas that some incentive programs use.
6) Add an incentive selection tool, similar to measure selection, that will enable the user to see outcomes with different incentive combinations.

Make It & Save It Template Instructions

<u>Purpose:</u> The Make It & Save It Template is an adaptation of the spreadsheet created by Pacific Crest Affordable Housing to help quantify the long-term value of investments in renewable energy and energy efficiency measures (EEMs) for its projects. It allows the user to define the scope and parameters of the project and can used for multiple purposes and project types, and at different points in project development. It has been organized to work through each tab sequentially.

<u>General Instructions:</u> Before starting, determine the scope and purpose of the analysis including the set of measures and systems you would like to evaluate. The Template can be used during the development process to evaluate design options, and updated as new information becomes available, or post-construction to inform future projects. The Measure Selection tool enables users to select combinations of measures as well as to compare alternative systems.

<u>Required Information:</u> Once the goal and scope of the analysis are determined, review the list of required information on the Introduction tab. Work with members of your project team, energy incentive programs and other industry resources, as necessary, to obtain energy and cost information for each measure and system, along with incentives. Recommendations for obtaining information are included throughout the Template worksheets. Make sure there is communication between team members to ensure energy and cost information is aligned in scope and specific measure parameters.

<u>Worksheet Inputs:</u> Read the instructions on each tab and enter the required information in the appropriate worksheets. Be sure to enter all information for each measure and system.

<u>Measure Selection & Output Dashboard:</u> Once measure and system information is entered on the worksheets, measures must be selected “Yes” on the Measure Selection tab to be included in the analysis. This allows alternative systems and different combinations of measures to be compared. The final Output Dashboard tab automatically performs a Life Cycle Cost Analysis and Net Present Value calculations, as well as a Make It & Save It comparison, based on the selected measures. Measures that are entered but not selected will not factor into the Template’s outputs.

<u>Suggested Approach:</u> Compare the first Year Zero cost in the upper left of the Life Cycle Cost Analysis with the Net Present Values directly below for a sense of the viability of the total proposed energy investments. A “good enough” payback and break-even point depend on the user’s interests and objectives. Pacific Crest applied a rule of thumb that allows a 20% margin for error, meaning an investment should still be good value at 80% of proposed performance to be a clear “yes” for inclusion in a project.

<u>Disclaimer:</u> *Pacific Crest Affordable Housing accepts no responsibility or liability for the information entered by the user, the accuracy of the spreadsheet’s calculations and outputs or the actual energy performance of projects that utilize the Template as a design tool.*

Appendix A: Project Summaries

Project Design Comparison

Canal Commons One Workforce & Family 48 Units: 1-, 2- and 3-bedrooms	Azimuth 315 Workforce & Family 50 Units: 1- and 2-bedrooms	IronHorse Lodge Senior 55+ 26 units: 1- and 2-bedrooms

Energy Performance Features:
Renewable Energy Production:
• 149 kW Solar Photovoltaic system
Energy Efficiency Measures:
• 16-Panel Solar Thermal hot water system
• LED Lighting with occupancy sensors
• ENERGY STAR Appliances
• Variable Refrigerant Flow ductless heating and cooling system with Energy Recovery Ventilator
• Wood frame with double-stud walls
• Building Envelope:
  • Attic insulation R-80
  • Wall insulation R-30
  • Windows U-0.29
  • Doors R-2
  • Reduced Infiltration (2.44 ACH50)
Certified Earth Advantage Platinum
	Energy Performance Features:
	Renewable Energy Production:
	• 107 kW Solar Photovoltaic system
	Energy Efficiency Measures:
	• 16-Panel Solar Thermal hot water system
	• LED Lighting with occupancy sensors
	• ENERGY STAR Appliances
	• Variable Refrigerant Flow ductless heating and cooling system with Energy Recovery Ventilator
	• Wood frame with double-stud walls
	• Building Envelope:
	  • Attic insulation R-60
	  • Wall insulation R-30
	  • Windows U-0.25
	  • Doors R-5
	  • Reduced Infiltration (2.44 ACH50)
	Certified Earth Advantage Platinum
		Energy Performance Features:
		Renewable Energy Production:
		• 64 kW Solar Photovoltaic system
		Energy Efficiency Measures:
		• 12-Panel Solar Thermal hot water system
		• LED Lighting with occupancy sensors
		• ENERGY STAR Appliances
		• Variable Refrigerant Flow ductless heating and cooling system with Energy Recovery Ventilator
		• Insulated Concrete Form walls
		• Building Envelope:
		  • Attic insulation R-60
		  • Wall insulation R-30
		  • Windows U-0.25
		  • Doors R-5
		  • Reduced Infiltration (2.44 ACH50)
		Certified Earth Advantage Platinum

Progressively Larger Solar PV Systems

Mountain Laurel Lodge
54 Units - Bend, OR
2006
18.3 kW Solar PV

Discovery Park Lodge
53 Units - Bend, OR
2009
14.9 kW Solar PV

Little Deschutes Lodge 1
26 Units - La Pine, OR
2010
24.0 kW Solar PV

Little Deschutes Lodge 2
26 Units - La Pine, OR
2013
32.2 kW Solar PV

IronHorse Lodge
26 Units - Prineville, OR
2016
64.09 kW Solar PV

Azimuth 315
50 Units - Bend, OR
2019
107.52 kW Solar PV

Canal Commons One & Two
96 Units - Bend, OR
2021 / 2023
297.39 kW Solar PV

Appendix B.1: Calibrated Modeling Methodology

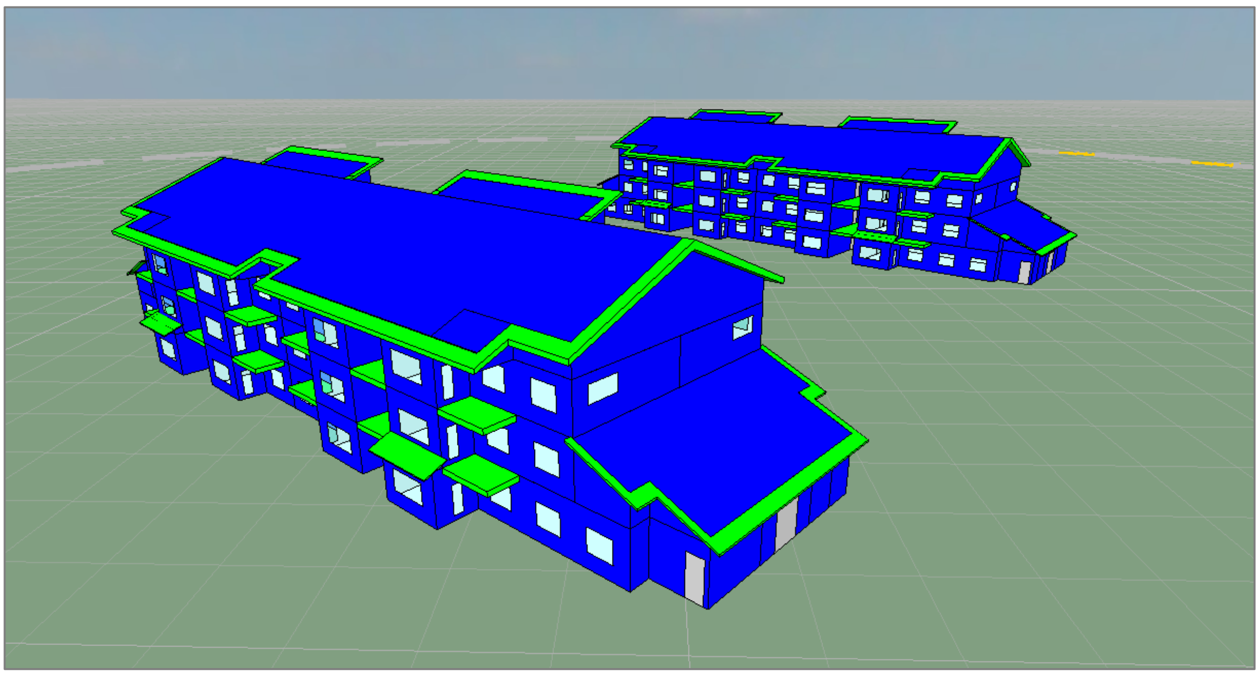
There were five steps in the calibrated modeling approach:

Step 0: Create Energy Model

In cases where the energy modeler has access to the original design-phase energy model and it was developed in sufficient detail to support calibration, this step can be skipped.

In this case, Zero Envy developed an "as-designed" energy model for Canal Commons One following the architectural and MEP design drawings as they normally would with a new project. Zero Envy also had access to some submittals and other information that gave a little more detail on installed systems and equipment.

Image of the 3D energy model developed for Canal Commons One in IESVE software:



Step 1: Collect & Analyze Data

The first step was collecting and analyzing available data to help inform the calibration process. At a minimum, this should include 12+ consecutive months of building energy usage information—typically based on utility bills. For the three projects included in this research, the following information was available:

- Electricity bills - Used to determine net electricity consumption and actual electricity costs.
- Natural gas bills - Used to determine gas consumption at the water heating plant and actual gas costs.

- Solar PV monitoring dashboard - Monthly generation data for the PV system.
- Variable Refrigerant Flow (VRF) HVAC energy metering data - However, the monitoring system was not working properly during the performance period and provided limited data.
- Electricity submetering system - This was also not available due to software licensing issues.
- Observations from on-site management team - On-site management and maintenance staff were able to follow up on specific inquiries and provide information from observations of the property.

Step 2: Calibrate the Energy Model

Energy model calibration is a time-consuming, iterative process and the specific steps will vary depending on the building type, passive and active systems, availability of measured data, modeling software and more. The high-level strategy is as follows:

1. Update model input(s).
2. Re-run simulation.
3. Compare results against actual consumption.
4. If variance still exists, determine the next update(s) to make.

The calibration is complete when the monthly energy consumption matches closely between the calibrated model and actual data. ASHRAE Guideline 14 defines specific criteria that should be followed to determine whether the data matches closely enough and calibration can be considered complete.

$$\mathrm{CVRMSE} = 100 \times \frac{\sqrt{\frac{\sum (y_i - \hat{y}_i)^2}{n-1}}}{\bar{y}} \qquad \text{(F-1)}$$

$$\mathrm{NMBE} = 100 \times \frac{\sum (y_i - \hat{y}_i)}{(n-p) \times \bar{y}} \qquad \text{(F-2)}$$

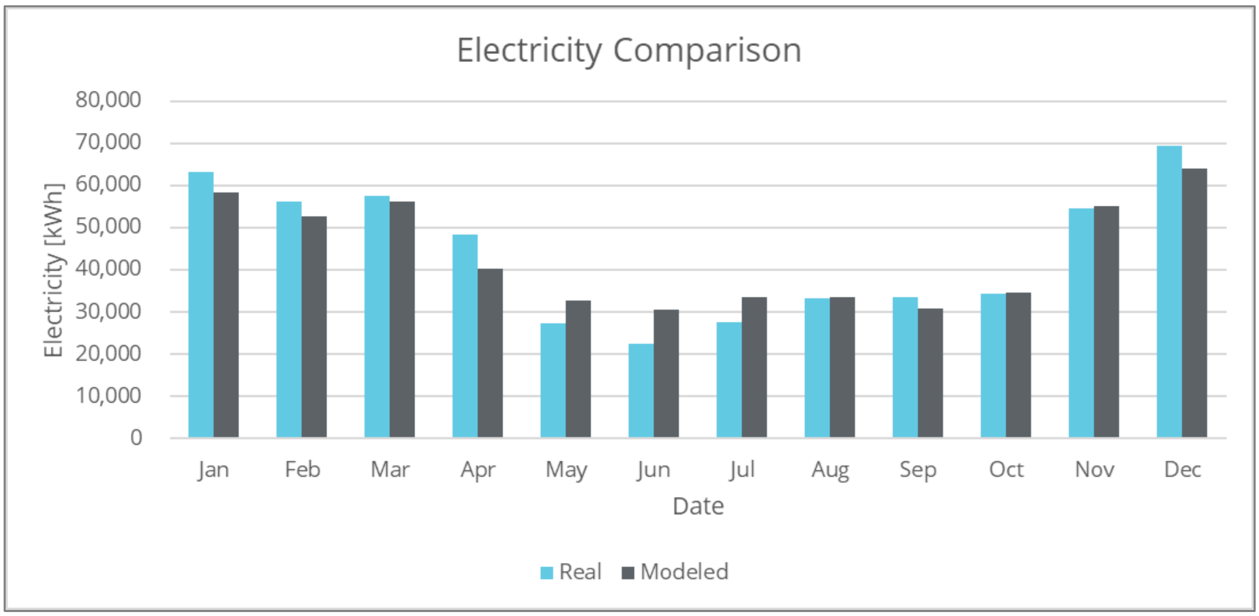
where

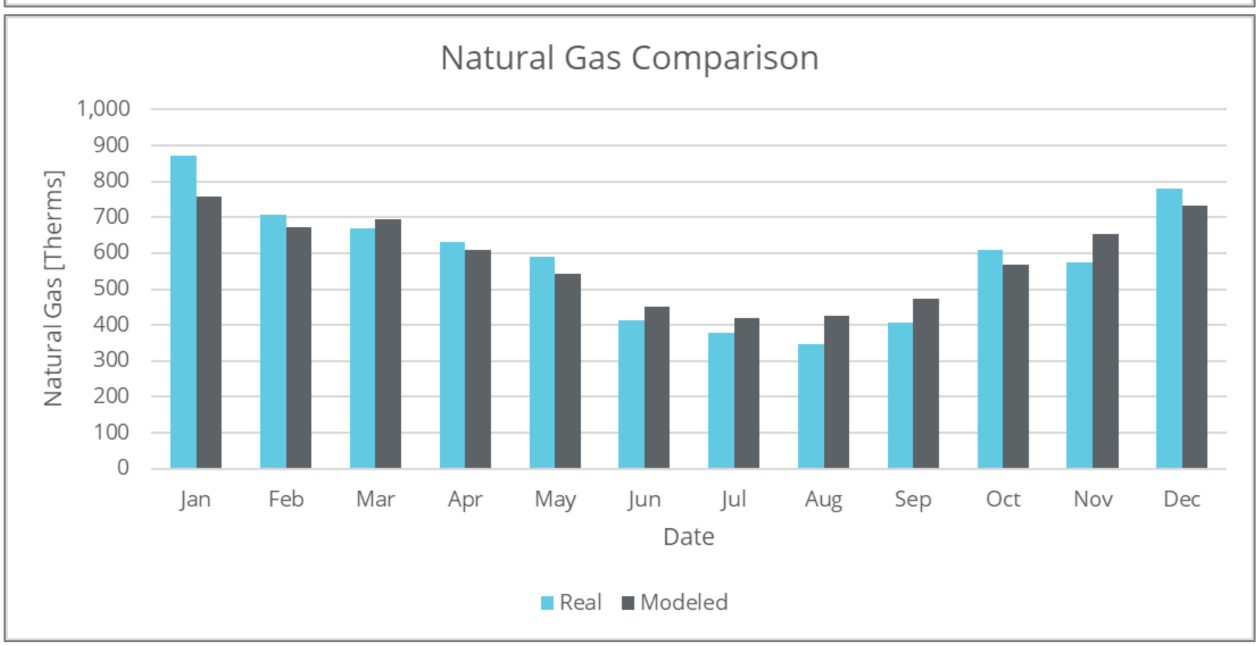
CVRMSE	=	coefficient of variation of the root-mean-square error
NMBE	=	normalized-mean-bias error
y	=	measured value
$\hat{y}$	=	model predicted value
$\bar{y}$	=	mean value of the measured data
n	=	number of data points in sample
p	=	P-value; for this purpose, $p = 1$

The equations should be applied to the monthly energy consumption for each energy source (electricity and natural gas, in the case of this project):

- CVRMSE ≤ 15%
- NMBE ≤ 5%

The graphs below show the monthly ***building*** energy consumption (i.e., excluding solar PV) when the calibration was complete for electricity and natural gas, respectively. Solar PV was excluded from the energy modeling calibration since the PV generation info was measured separately and its impact could be easily post-processed separately from the energy model.





The energy model revisions that led to the calibrated model were as follows:

- **Update weather file:** Design energy models typically use TMY3 or Mix weather files which are developed to represent typical weather conditions based on historical data. Calibrated models should use actual weather data which can be purchased or developed. In this case, Zero Envy used an internally developed Python script to adjust a TMYx EPW file using hourly actual data from the NOAA Climate Data Online (CDO) web API.
- **Natural Gas for Domestic Hot Water (DHW):** DHW was the next area of focus since it's the only system using natural gas on site. This system used centralized, natural gas-fired, condensing water heaters, insulated storage tank and solar thermal panels to pre-heat the water. The original "as-designed" model results showed DHW gas usage about 15% less than actual consumption. Adjusting this system included the following model updates, with the first two being used to match seasonal fluctuations in consumption, whereas the last has a stable impact on monthly consumption:
  - **Makeup water temperature:** The input parameter that had the greatest effect was updating the generic "monthly ground water temperature profile" based on conditions more appropriate for Central Oregon. The default profile ranged from 57 – 63°F with an annual mean of 60°F. The adjusted version used the "Ground Temperature" graphic in the Climate Consultant software and local TMY3 file based on a 6.5-ft ground depth resulting in an annual average of 48°F.
  - **Solar thermal:** The modeling software was able to explicitly model the solar water heating system. After adjusting the makeup water temperature, the modeled consumption was higher than the actual consumption. Increasing the efficiency parameters of the solar thermal system from initial assumptions reduced the total consumption and helped produce a better monthly fit.
  - **DHW load:** While Zero Envy did adjust the peak demand flow rate in the calibrated model, the final value was almost exactly the same as the original as-designed assumption of 197 gal/hr for each of the two buildings. This value was calculated using Chapter 50 from the 2015 ASHRAE Handbook of Fundamentals. The hourly profile used was developed with research data used for energy code development in California and was not adjusted during calibration.
- **Electricity:** When beginning to calibrate the electricity use of the model, building electricity consumption for the as-designed model was 36% less than actual consumption, and the variance was much higher in winter months than in the months from May through October. The major electricity calibration measures are described below:
  - **Heating/cooling temperature setpoints:** The heating/cooling setpoints both needed to increase, from 70 / 75 → 74 / 77°F. This was informed by the seasonal fluctuations as the building needs to increase electricity consumption in winter months and

decrease it slightly in the summer. There were also reported site observations where tenants had unreasonably high setpoints in winter months (although reliable, consistent data on setpoints was not available beyond this). While the model was still lower for winter consumption, it did not feel appropriate to increase the heating temperature setpoint higher than 74°F (and even a 78°F setpoint wouldn't resolve the discrepancy on its own).

- **Increase infiltration:** The initial infiltration assumption was too low in our as-designed model. Zero Envy needed to update the infiltration to be in alignment with multifamily modeling protocols and the design-phase EEMs for the project. The initial assumption of 0.1 ACH increased to 0.53 ACH, which corresponds to the design infiltration rate of 3.5 ACH_{50} (e.g., infiltration in air changes/hour at a natural pressure of 4 Pascals vs. pressurized to 50 Pascals). This change increased consumption and both calibration variables.
- **Increase plug loads:** Overall electricity use was still low after the prior changes, so the equipment power density ("plug loads") input for residential units was increased from 0.5 → 0.72 W/ft². This change alone made summer consumption higher in the calibrated model than actuals, so Zero Envy also adjusted the hourly schedules to have slightly increased use in winter months (+20) compared to the rest of the year. This change did not fully resolve the remaining variance, but the modelers weren't comfortable with continuing to increase this value without having measured data to support it.
- **VRF system performance curves:** The modeling software had three different options for VRF system performance curves — a "generic" curve set based on codes and standards development work and two manufacturer curves. The generic curves resulted in relatively low average efficiencies and helped the modeled consumption be very close to actual consumption. However, they were ultimately too conservative and showed negligible savings compared to the code-minimum packaged terminal heat pump. Therefore, Zero Envy selected a different curve that aligned more closely with manufacturer data of the installed systems. The relatively higher efficiencies of these curves resulted in an *increased* gap between modeled and actual consumption. Without having more granular measured data, it was impossible to calibrate this measure further with any confidence.
- **Open windows in two (2) units:** The project has operable windows in all apartments. The windows had originally been left closed in the model. Operable windows are typically thought of as an energy efficiency measure, and Zero Envy wanted to start with a conservative approach. The model was still not matching the high actual electricity consumption, and the research team had conversations with on-site personnel who mentioned observing windows left open in the colder months. The

windows are manually operated and do not have window interlocks or any means of monitoring their position, but it was worth evaluating. Based on this, Zero Envy ran some iterations in the model to leave certain windows open in the model. Opening windows in two (out of 24) apartments in the colder months allowed the model to meet the calibration thresholds on the first round of calibration. After selecting the more efficient VRF curves, however, the model was out of calibration and needed open windows in more apartments to achieve calibration once again. The second time, all the windows were opened by 3% in one of the two buildings (half of the total apartments) whenever the outside temperature was below 70°F. While this change allowed for calibration, this final measure was not used in the re-analysis of EEMs.

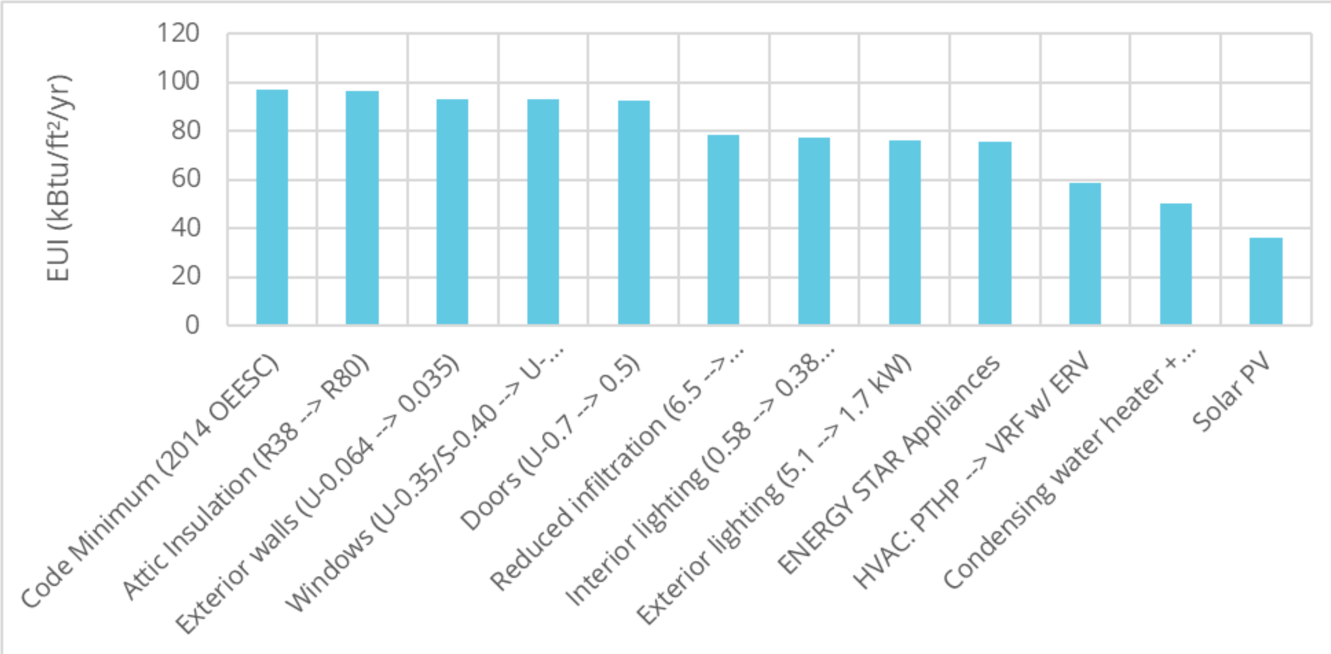
Step 3: Re-Analyze EEMs

After having a model that aligned more closely with actual operations, Zero Envy set out to re-evaluate the EEMs included in the original design. This would help to validate the selected EEMs with more realistic savings and ensure they remain worthy of the up-front investment. As mentioned in the prior step, Zero Envy decided not to leave the windows open in this exercise as it has such a major impact on HVAC and envelope EEMs. Therefore, the re-analysis of EEMs used a "semi-calibrated" version of the model.

The EEM analysis consisted of creating a new code minimum baseline model based on the semi-calibrated design model, and then incrementally adding each EEM along the way. This "incremental" or "cumulative" modeling approach provides individual savings that can be totalized.

The evaluated measures were as follows, where the code minimum and proposed design values are referenced where appropriate:

1. Attic Insulation (R38 → R80)
2. Exterior walls (U-0.064 → 0.035)
3. Windows (U-0.35/S-0.40 → U-0.29/S-0.21)
4. Doors (U-0.7 → 0.5)
5. Reduced infiltration (6.5 → 3.5 ACH50)
6. Interior lighting (0.58 → 0.38 W/ft2)
7. Exterior lighting (5.1 → 1.7 kW)
8. ENERGY STAR Appliances
9. HVAC: PTHP → VRF w/ ERV
10. Condensing water heater + solar thermal
11. Solar PV



Step 4: Adjust EEM Results to Apply to Other Projects

As mentioned earlier, the research project includes three buildings, but the detailed calibration only applied to one. Since most of the EEMs are comparable between the projects, Zero Envy started with the actual measured energy usage for Azimuth 315 and IronHorse Lodge and then subtracted the energy savings per square foot from each measure. The exception to this approach was the insulated concrete forms (ICF) exterior wall type that was used for the IronHorse Lodge project. In that case, Zero Envy built the ICF construction into the Canal Commons One model to determine the increased energy savings and used those refined savings instead.

Note that energy savings from EEMs in one project are usually not transferable to another project, and this kind of strategy should be considered and applied carefully. In the case of this project, the buildings were similar designs built a couple of years apart in the same climate. The team faced trade-offs given limited time and chose to spend it on a more thorough model and analysis of one project instead of spreading that effort thinly across all three.

Appendix B.2: Calibrated Modeling Results

Canal Commons One - Calibrated Model Results

#	MEASURE DESCRIPTION	ELECTRICITY				NATURAL GAS				TOTAL ENERGY COST			SITE ENERGY USE		
		[kWh]	[kWh svgs]	[kWh svgs add'l]	[kWh/ft2 svgs add'l]	[therm]	[therm svgs]	[therm svgs add'l]	[therm/ft2 svgs add'l]	[$]	[$ svgs]	[$ svgs add'l]	[kBtu/sf-yr]	add'l	[% svgs]
B A S E L I N E (S)															
0	Code Minimum (2014 OEESC)	948,284	-	-	-	10,833	-	-		$121,094	-	-	96.8	-	-
E N E R G Y E F F I C I E N C Y M E A S U R E S															
1	Attic Insulation (R38 --> R80)	941,141	7,142	7,142	0.160	10,833	0	0	0.000	$120,279	814	814	96.3	0.5	0.6%
2	Exterior walls (U-0.064 --> 0.035)	901,292	46,991	39,849	0.893	10,833	0	0	0.000	$115,737	5,357	4,543	93.2	3.0	3.7%
3	Windows (U-0.35/S-0.40 --> U-0.29/S-0.21)	898,730	49,553	2,562	0.057	10,833	0	0	0.000	$115,445	5,649	292	93.0	0.2	3.9%
4	Doors (U-0.7 --> 0.5)	888,968	59,315	9,762	0.219	10,833	0	0	0.000	$114,332	6,762	1,113	92.3	0.7	4.7%
5	Reduced infiltration (6.5 --> 3.5 ACH50)	711,448	236,836	177,521	3.979	10,833	0	0	0.000	$94,094	26,999	20,237	78.7	13.6	18.7%
6	Interior lighting (0.58 --> 0.38 W/ft2)	692,457	255,826	18,991	0.426	10,833	0	0	0.000	$91,929	29,164	2,165	77.2	1.5	20.2%
7	Exterior lighting (5.1 --> 1.7 kW)	676,227	272,056	16,230	0.364	10,833	0	0	0.000	$90,079	31,014	1,850	76.0	1.2	21.5%
8	ENERGY STAR Appliances	673,889	274,395	2,339	0.052	10,833	0	0	0.000	$89,813	31,281	267	75.8	0.2	21.7%
9	HVAC: PTHP --> VRF w/ ERV	448,834	499,449	225,055	5.044	10,833	0	0	0.000	$64,156	56,937	25,656	58.6	17.2	39.5%
10	Condensing water heater + solar thermal	449,830	498,453	(996)	(0.022)	7,003	3,830	3,830	0.086	$59,677	61,416	4,479	50.1	8.5	48.2%
11	Solar PV	268,197	680,086	181,633	4.071	7,003	3,830	0	0.000	$38,971	82,122	20,706	36.2	13.9	62.6%
I N T E R A C T I V E C O M B I N A T I O N S															
A	Total EEMs ("Save its") (incl. solar thermal)			498,453	11.172			3,830	0.086						
B	Total Renewables ("Make its")			181,633	4.071			0	0.000						

Notes:

Gross floor area:	44,618
Actual Bldg Electricity (kWh/yr)	526,951
Actual Natural gas (kWh/yr)	7,003
Actual PV generation (kWh/yr)	(181,633)
Electricity rate ($/kWh)	0.114
Natural gas rate ($/therm)	1.199

Appendix C: Updated Financial Model Results

Canal Commons One – Updated Financial Model

Summary of Inputs

Project Information	
Property Name	Canal Commons One
Total Building Square Footage (sf)	44,916
Cost of Energy	
Electric Utility Rate ($/kWh)	$0.114
Net Meter Credit Ratio Adjuster (%)	100%
Natural Gas Utility Rate ($/Therm)	$1.199
Annual Energy Usage & Production	
Code Minimum Building Electricity (kWh)	948,284
Proposed Electricity Usage (kWh)	268,196
Code Minimum Building Natural Gas (Therms)	10,833
Proposed Natural Gas Usage (Therms)	7,003
Estimated Renewable Energy (kWh)	181,633
Estimated Renewable Energy (Therms)	0
Project Costs	
Incremental Costs of EEMs ($)	$937,937
Renewable Energy System Costs ($)	$322,910
Financial Incentives	
Energy Efficiency Incentives Total ($)	$309,624
Renewable Energy Incentives Total ($)	$250,149
Financial Assumptions	
Energy Cost Inflation Adjuster [%/Yr]	3.25%
Discount Rate [%/Yr]	4.00%

Model Outputs
Template Version 10/15/24

Net Annual Benefit		
Total kWh Saved (kWh)	498,455	$56,824
Total Therms Saved (Therms)	3,830	$4,592
Total kWh Offset (kWh)	181,633	$20,706
Net Annual Benefit (first year)		**$82,122**

Energy Use Intensity (EUI)			
Baseline (Code Minimum) Project EUI		96.2	kBTU/sf/year
Canal Commons One	**Net EUI**	36.0	kBTU/sf/year

Life Cycle Cost Analysis* (Net Detriments and Benefits Flow)	# Years										
	0	1	2	3	4	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	**-$701,074**	$82,122	$84,791	$87,547	$90,392	$93,330	$96,363	$109,514	$150,790	$207,622	$285,873
Cumulative Detriments & Benefits [$]	-$701,074	-$618,952	-$534,161	-$446,614	-$356,222	-$262,892	-$166,529	$251,276	$1,562,562	$3,368,065	$5,854,050
Break-Even [#Yrs]											

*Does not include equipment lifespans and replacement costs, which affect the projected payback at longer timelines.
**Break-Even may be hidden in the LCCA table because the table has been condensed. It is displayed in the NPVs table below.

NPVs of Life Cycle Cost Analysis	
20-Yr Net Present Value [$]	**$744,755**
30-Yr Net Present Value [$]	**$1,380,785**
40-Yr Net Present Value [$]	**$1,972,407**
Break-Even [# Yrs]	**8**

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	**610,674**	**$ 937,937**	**$ 1.54**	**$ 628,313**	**$ 1.03**
Make It	**181,633**	**$ 322,910**	**$ 1.78**	**$ 72,761**	**$ 0.40**
Combo	**792,307**	**$ 1,260,847**	**$ 1.59**	**$ 701,074**	**$ 0.88**

*Includes solar thermal & DHW savings converted from Therms to kWh

Azimuth 315 - Updated Financial Model

Summary of Inputs

Project Information	
Property Name	Azimuth 315
Total Building Square Footage (sq ft)	46,348
Cost of Energy	
Electric Utility Rate ($/kWh)	$0.114
Net Meter Credit Ratio Adjuster (%)	100%
Natural Gas Utility Rate ($/Therm)	$1.199
Annual Energy Usage & Production	
Code Minimum Building Electricity (kWh)	1,030,154
Proposed Electricity Usage (kWh)	358,626
Code Minimum Building Natural Gas (Therms)	7,781
Proposed Natural Gas Usage (Therms)	3,802
Estimated Renewable Energy (kWh)	153,748
Estimated Renewable Energy (Therms)	0
Project Costs	
Incremental Costs of EEMs ($)	$632,891
Renewable Energy System Costs ($)	$386,581
Financial Incentives	
Energy Efficiency Incentives Total ($)	$208,611
Renewable Energy Incentives Total ($)	$382,728
Financial Assumptions	
Energy Cost Inflation Adjuster [%/Yr]	3.25%
Discount Rate [%/Yr]	4.00%

Model Outputs
Template Version 10/15/24

Net Annual Benefit		
Total kWh Saved (kWh)	517,780	$59,027
Total Therms Saved (Therms)	3,979	$4,771
Total kWh Offset (kWh)	153,748	$17,527
Net Annual Benefit (first year)		**$81,325**

Energy Use Intensity (EUI)			
Baseline (Code Minimum) Project EUI		92.6	kBTU/sq ft/year
Azimuth 315	**Net EUI**	34.6	kBTU/sq ft/year

Life Cycle Cost Analysis* (Net Detriments and Benefits Flow)	# Years										
	0	1	2	3	4	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	**-$428,133**	$81,325	$83,968	$86,697	$89,515	$92,424	$95,428	$108,451	$149,326	$205,606	$283,098
Cumulative Detriments & Benefits [$]	-$428,133	-$346,808	-$262,840	-$176,143	-$86,628	$5,796	$101,223	$514,973	$1,813,529	$3,601,505	$6,063,358
Break-Even [# Yrs]**						B/E					

*Does not include equipment lifespans and replacement costs, which affect the projected payback at longer timelines.
**Break-Even may be hidden in the LCCA table because the table has been condensed. It is displayed in the NPVs table below.

NPVs of Life Cycle Cost Analysis	
20-Yr Net Present Value [$]	**$993,425**
30-Yr Net Present Value [$]	**$1,623,280**
40-Yr Net Present Value [$]	**$2,209,160**
Break-Even [# Yrs]	**5**

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	**634,365**	**$ 632,891**	**$ 1.00**	**$ 424,280**	**$ 0.67**
Make It	**153,748**	**$ 386,581**	**$ 2.51**	**$ 3,853**	**$ 0.03**
Combo	**788,113**	**$ 1,019,472**	**$ 1.29**	**$ 428,133**	**$ 0.54**

*Includes solar thermal & DHW savings converted from Therms to kWh

Appendix C: Updated Financial Model Results

IronHorse Lodge - Updated Financial Model

Summary of Inputs	
Project Information	
Property Name	IronHorse Lodge
Total Building Square Footage (sq ft)	27,540
Cost of Energy	
Electric Utility Rate ($/kWh)	$0.114
Net Meter Credit Ratio Adjuster (%)	100%
Natural Gas Utility Rate ($/Therm)	$1.199
Annual Energy Usage & Production	
Code Minimum Building Electricity (kWh)	560,346
Proposed Building Electricity Usage (kWh)	133,328
Code Minimum Building Natural Gas (Therms)	3,777
Proposed Natural Gas Usage (Therms)	2,364
Estimated Renewable Energy (kWh)	93,525
Estimated Renewable Energy (Therms)	0
Project Costs	
Incremental Costs of EEMs ($)	$311,759
Renewable Energy System Costs ($)	$192,153
Financial Incentives	
Energy Efficiency Incentives Total ($)	$167,548
Renewable Energy Incentives Total ($)	$183,456
Financial Assumptions	
Energy Cost Inflation Adjuster [%/Yr]	3.25%
Discount Rate [%/Yr]	4.00%

Model Outputs

Template Version 10/15/24

Net Annual Benefit		
Total kWh Saved (kWh)	333,493	$38,018
Total Therms Saved (Therms)	1,413	$1,694
Total kWh Offset (kWh)	93,525	$10,662
Net Annual Benefit (first year)		**$50,374**

Energy Use Intensity (EUI)			
Baseline (Code Minimum) Project EUI		83.1	kBTU/sq ft/year
IronHorse Lodge	**Net EUI**	25.1	kBTU/sq ft/year

Life Cycle Cost Analysis* (Net Detriments and Benefits Flow)	# Years 0	1	2	3	4	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	**-$152,908**	$50,374	$52,011	$53,702	$55,447	$57,249	$59,110	$67,177	$92,495	$127,356	$175,356
Cumulative Detriments & Benefits [$]	-$152,908	-$102,534	-$50,522	$3,179	$58,626	$115,876	$174,985	$431,269	$1,235,620	$2,343,125	$3,868,043
Break-Even [#Yrs]**				B/E							

*Does not include equipment lifespans and replacement costs, which affect the projected payback at longer timelines.

**Break-Even may be hidden in the LCCA table because the table has been condensed. It is displayed in the NPVs table below.

NPVs of Life Cycle Cost Analysis	
20-Yr Net Present Value [$]	**$723,313**
30-Yr Net Present Value [$]	**$1,113,457**
40-Yr Net Present Value [$]	**$1,476,362**
Break-Even [# Yrs]	**3**

Save vs. Make $/kWh	kWh/Yr	w/o Incentives [$] 1st Cost	w/o Incentives [$] $/kWh	w/ Incentives [$] 1st Cost	w/ Incentives [$] $/kWh
Save It*	**374,894**	**$ 311,759**	**$ 0.83**	**$ 144,211**	**$ 0.38**
Make It	**93,525**	**$ 192,153**	**$ 2.05**	**$ 8,697**	**$ 0.09**
Combo	**468,419**	**$ 503,912**	**$ 1.08**	**$ 152,908**	**$ 0.33**

*Includes solar thermal & DHW savings converted from Therms to kWh

Appendix D: Resident Listening Session Summary

Purpose and Methods

The Pacific Crest research team met with residents at Azimuth 315 on Thursday, June 6. This semi-structured conversation provided residents with an opportunity to voice questions, learn about the design and function of the building's systems and provide feedback.

The listening session was attended by:

- 12 Azimuth 315 residents
- Kristalyn W., Azimuth 315 Site Manager
- Jim Landin, LRS Architects and the architect for Pacific Crest's projects
- ML Vidas, Senior Market Outreach Manager, New Buildings, Energy Trust of Oregon
- Rob Roy and Ben Bergantz, Pacific Crest Affordable Housing

To encourage a relaxed and open dialogue, the open-ended questions were organized by building system. When appropriate, specific building components and systems were introduced with an explanation including the "how" and "why" of their design and function. Residents seemed ready and willing to engage on specific aspects of their apartments and building, and the presence of the building's architect encouraged residents to ask questions about the building design. Additional questions about how to engage residents around saving energy were asked toward the end of the meeting.

Open-ended questions:
"What do you think about the…"
"What is your experience with…"

Building systems:

- HVAC
- Lighting
- Ventilation
- Hot Water

Additional questions:
"How can we help you save energy and be good climate stewards?"
"What kind of incentives/information would motivate you to help save energy in our building?"
"What's the best way to share information about how to save energy?"

Summary of Feedback

<u>Heating and Cooling:</u>

- Given the lack of "feedback" from the VRF and central controls, some uncertainty about whether the VRF system was working or residents are using it correctly.

- One resident expressed desire to use a plug-in heating appliance in winter, but these are not permitted under the lease and not advised based on energy use.
- Multiple residents noted that the interior door gaskets were worn and no longer providing a good seal, and expressed concern this was causing the VRF to use more heating and cooling energy.
- A building-wide outage of the central VRF heating and cooling system that occurred during extremely cold weather in January 2024 highlighted a vulnerability of a central VRF system (versus decentralized mini splits). The VRF requires specialized service, which we were fortunate to get in this instance to get the building re-heated, enabling residents to stay in their apartments. This led to conversation about resiliency.

<u>Lighting:</u>
- Residents are satisfied with lighting.
- Residents appreciated design efforts to increase natural lighting.
- Residents noted differences in amounts of sunlight and warmth entering apartments depending on which side of the building you are on and time of day.

<u>Fresh Air (Ventilation):</u>
- Concern from one resident about the placement of the ERV vent blowing cool air in the direction of the kitchen stovetop.
- Air filters, which residents are currently required to replace themselves, are difficult for some residents to reach.
- Residents expressed concern about wildfire smoke. PCAH explained that scrubbers have been installed to handle particulates during wildfire season, and instructed residents to keep windows closed and locked to get the tightest seal when the air quality outside was poor.

<u>Hot water:</u>
- Residents are satisfied with hot water supply.

<u>How can we help you save energy? What kind of incentives/rewards would help motivate you?</u>
- There was a feeling that residents can benefit from education about the systems in their apartments and building and how they are designed to work.
- Many attended past building events focused on saving energy.
- Some residents are too busy or not interested in learning about saving energy.

<u>What is the best way to share information about how to save energy?</u>
- Flyers in mail cubbies do not work; using the lobby TV to display information would be more effective.
- Many people in the building work at different hours and may not be able to attend events and meetings in the daytime or evenings. Meeting times should be varied and include weekends to give everyone an opportunity to attend.

Appendix E: Template Peer Review Summary

The research team reviewed the Make It & Save It Template with five peer reviewers:

- Clayton Crowhurst, NW Housing Alternatives (in-person meeting, 7/18)
- Rachel Naujock, Hacienda CDC (virtual meeting, 7/19)
- Rosanne Lynch, Access Architecture (virtual meeting, 7/19)
- David Heslam, Earth Advantage (email and conference call, 7/23)
- Jim Landin, LRS Architects (phone call, 8/15)

Summary of Feedback & Comments

- It is helpful to see the impact of energy investments on operating costs and the annual net benefit. A developer may want to incorporate the outputs into a project's Pro Forma.
- Owners who do not pay resident utilities and only experience financial benefits from utility cost savings for common areas—most multifamily housing owners—may find it helpful to have the resident apartment and common area energy use separated.
- PCAH could help other developers learn to maximize incentives for solar PV.
- Many developers already have their own process, people and systems to make design decisions. They may not need a deep analysis to feel comfortable with measures they have used before that went well.
- It helps to have all the output information in one place. People already in-the-know may not find it impactful but someone new to the table who needs to understand the benefits of energy investments may find the dashboard useful.
- Getting information may be a challenge earlier in the design process when decisions need to be made, e.g., wall type. Potentially more accurate information is available further along in the development process, but there is less freedom to make changes as you get closer to a final project design. This affects when and how the tool may be most useful.
- The Net Meter Credit Ratio is an interesting addition although there is some question about how it works. It is good to incorporate a variable because net meter agreements will change in the future.
- It is difficult to get a good average estimate of utility rates over 40 years. Rates are going up now but could go down in 20 years, so it's hard to accurately predict.
- Using kBTUs as the primary unit of energy would normalize energy comparisons and simplify EUI calculations.
- The absence of equipment lifespans and replacement costs in the Life Cycle Cost Analysis reduces the accuracy of the Net Present Value calculations at longer timelines (i.e., 30 or 40 years), because these costs are not factored.
- Developers and owners have different time horizons, impacting how they view the break-even timeline and long-term benefits.
- It is a great addition to the market for PCAH to be sharing from a developer perspective the process that it used and how it thought about decisions.
- Attention needs to be paid to what happens once the building opens, to ensure that EEMs and renewable systems are performing as designed.