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 Presentation

Rob Roy
Pacific Crest Affordable Housing

Ben Bergantz
Pacific Crest Affordable Housing

Greg Collins
Zero Envy

Net Zero Fellowship Presentation Agenda

1) Introduction
2) Pacific Crest's Approach to Sustainability
3) Research Goals & Methods
4) Research Results
5) Recommendations
6) Acknowledgements
7) Questions & Discussion

1. Introduction

Pacific Crest Affordable Housing

- For-profit developer based in Bend, OR building affordable housing since 2005
- Eight completed affordable multifamily apartment properties, all located in Central Oregon, offering 331 total units
- Properties serve households earning 60% Area Median Income and below
- The four most recent projects were certified Earth Advantage Platinum

2. Approach to Sustainability

Pacific Crest Affordable Housing

Our mission is to provide high quality, comfortable, and stable housing which our tenants are proud to call home, and **to contribute to the advancement of sustainable building** in affordable housing development.

- Bringing a developer perspective:
  Optimize investments & maximize value

Pacific Crest's "Save It" & "Make It" Spreadsheet

NPVs of Energy Savings
OR Code Minimum vs IronHorse 1

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 [$/kWh]	0.137	Pacific Power OR Sch 28 (No Facilities Charge)
Gross Building Square Footage [SF]	27,540	IHL Actual GBSF
Discount Rate [%/Yr]	4.00%	Market Driven (WACC - Cost of Capital)
EEMs* 1st Costs w/o Incentives[$]	242,431	Data Assembled for ETO-PTNZ (Qualifying Costs)
EEMs Incentive Amount	119,639	Data Assembled for ETO-PTNZ & After Tax
EEMs 1st Costs w /Incentives	122,792	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 [$]	513,848	Calculated Final Result
Total 1st Costs [$] w/ Incentives [$]	181,542	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 Proforma
Results

Other Inputs Energy Usage/SF/Yr & /Yr/Bldg	Conversion kBTUs-->KWh		kWh/Yr/Bldg
	kBTU/SF/Yr	kWh/SF/Yr	
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 [$/Yr]	(181,542)	34,642	39,370	40,650	46,197	63,609	87,583	120,592
Cumulative Detriments & Benefits [$]	(181,542)	(146,900)	3,300	43,950	220,196	773,346	1,534,976	2,583,660
Breakeven [#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 [$] D&BF	423,972
30-Yr Net Present Value [$] D&BF	692,273
40-Yr Net Present Value [$] D&BF	941,842
Breakeven [# Yrs]	5

Save vs Make $/kWh	Save.Make kWh/Yr	w/o Incentives [$] 1st Cost	w/o Incentives [$] $/kWh	w/ Incentives 1st Cost	w/ Incentives $/kWh
Save It	130,681	$ 242,431	$ 1.86	$ 122,792	$ 0.94
Make it	122,754	$ 271,417	$ 2.21	$ 58,750	$ 0.48
Combo	253,435	$ 513,848	$ 2.03	$ 181,542	$ 0.72

Key Inputs:

- Estimated energy savings
- Incremental costs
- Utility rates
- Financial incentives

Key Outputs:

- Life Cycle Cost Analysis
- Net Present Value
- Save vs Make cost per kWh comparison

Sustainability Design

Energy Efficiency Measures (EEMs) = “Save Its”

Whole-building energy efficiency

Design highlights:

- Central HVAC – Variable Refrigerant Flow w/ERV
- Central hot water w/solar thermal pre-heat
- High-heel Truss Design
- Thermal Breaks Windows, Doors and Top Plates (built on-site)
- Cold roof, 6/12 pitch, code x2 ventilation

Sustainability Design

Renewable Energy Production = “Make Its”

Properties are master metered with net metering

- Utilities are included in the rents


IronHorse Lodge 64 kW Solar PV


Azimuth 315 107 kW Solar PV


Canal Commons One 148 kW Solar PV

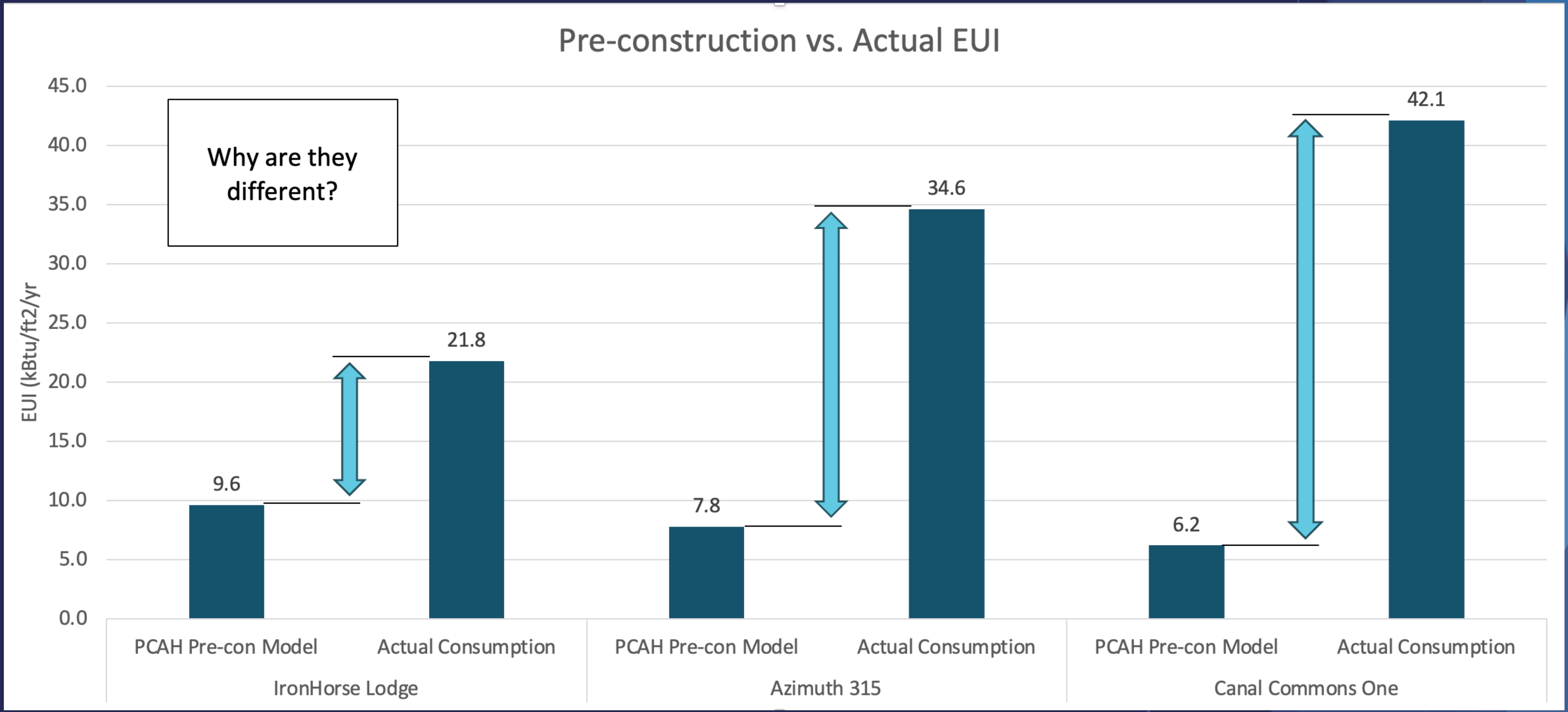
Sustainability Beyond Energy

Pacific Crest Lavender & Honey

- Lavender sequesters carbon in plant root structure and provides habitat for pollinators.

3. Research Goals & Methods

The Problem: Predicted vs. Actual Energy Performance



- EUI = Energy Use Intensity (kBtu / sq ft / year)

Research Focused On Three Properties

IronHorse Lodge

Prineville, OR
26 Units
Seniors 55+

Completed 2016

Azimuth 315

Bend, OR
50 Units
Workforce & Family

Completed 2019

Canal Commons One

Bend, OR
48 Units
Workforce & Family

Completed 2020

"Why is energy use so much higher than predicted?"

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.

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.

4. Research Results

Goal #1: Understand difference between pre-construction and actual energy performance.

"Are the solar PV systems working as designed?" In short, yes!

Project	PVWatts Annual kWh	Measured Annual kWh (Oct 2022 – Oct 2023)
IronHorse Lodge	95,254	93,525
Azimuth 315	145,246	153,748
Canal Commons One	213,211	181,033*

*Canal Commons One had a PV outage in 2023. The average annual solar PV production for the previous two years was 216,900 kWh per year (102% of PVWatts estimate).

What about the modeling and EEMs?

"Were the original energy models overly optimistic?"

"Are the EEMs underperforming?"

Calibrated Energy Model Steps:

1. Created a new energy model for Canal Commons One based on as-built design

2. Collected & analyzed data
   - Utility bills, PV data, submetering, onsite observations

3. Model was calibrated to align with measured data

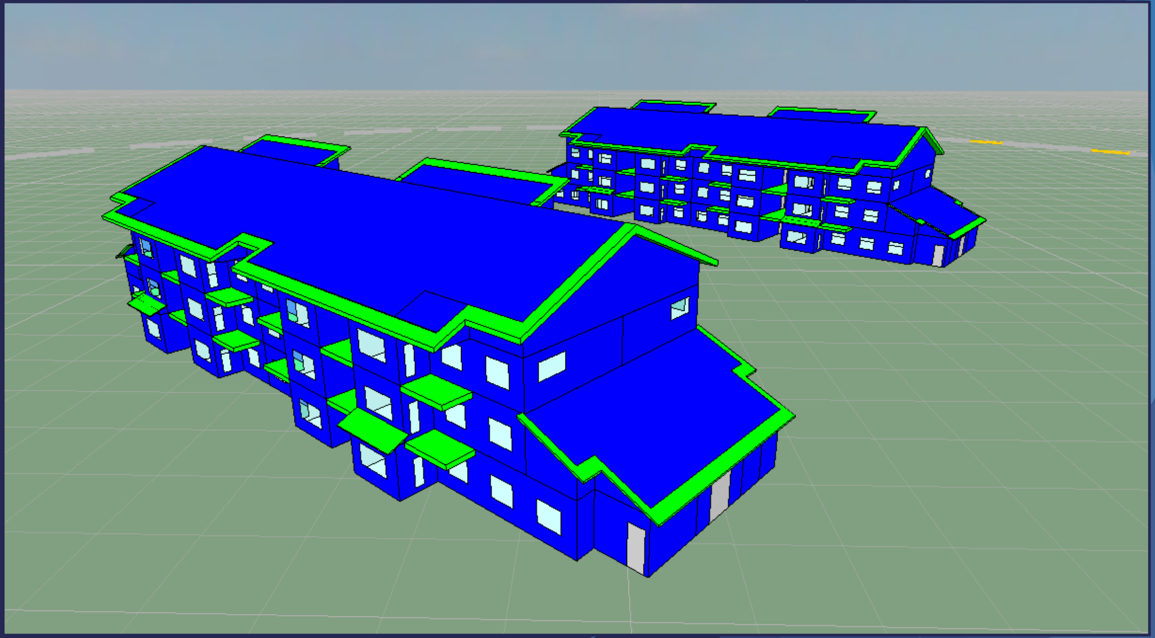
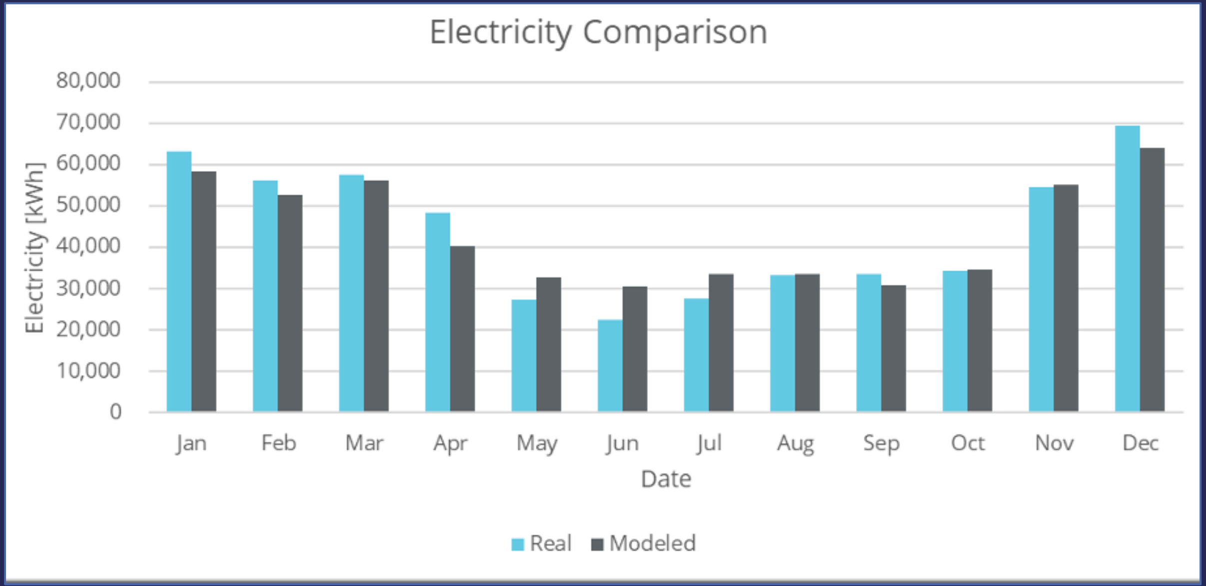
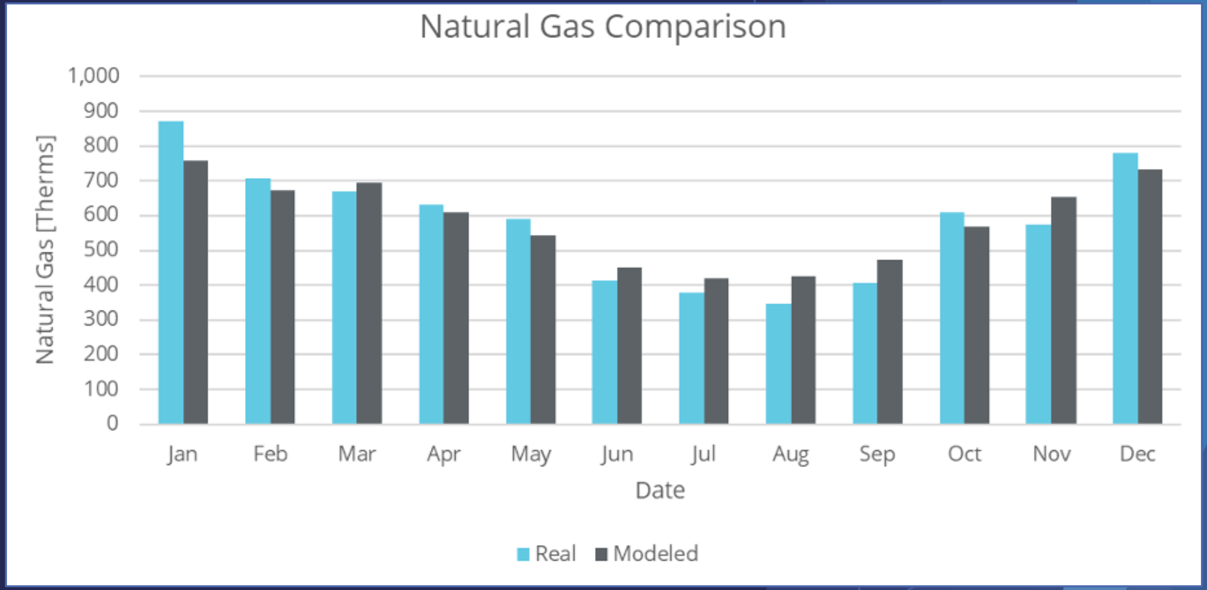


Image of the 3D energy model developed for Canal Commons One in IESVE software

Calibrated Energy Model vs. Actual Energy Consumption



Electricity comparison

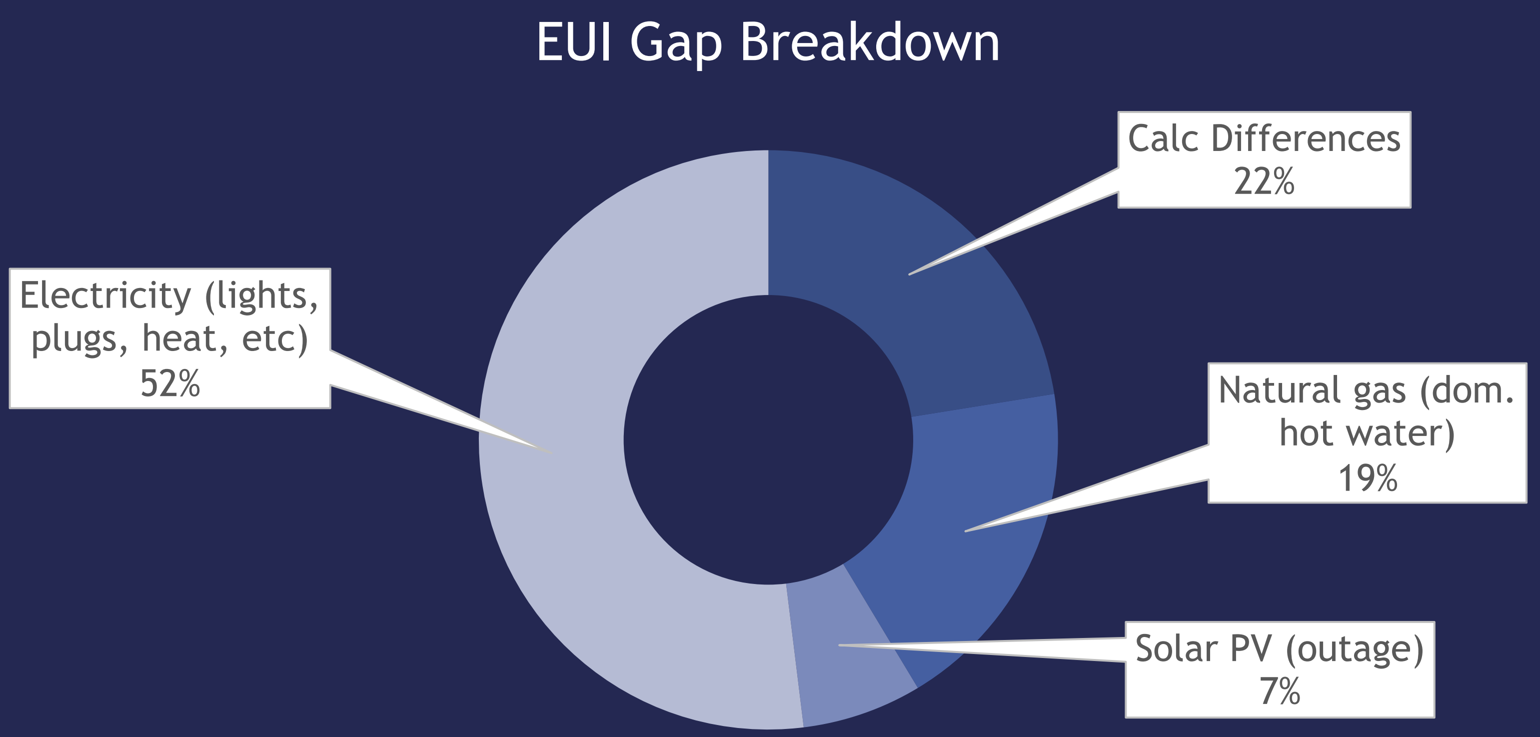


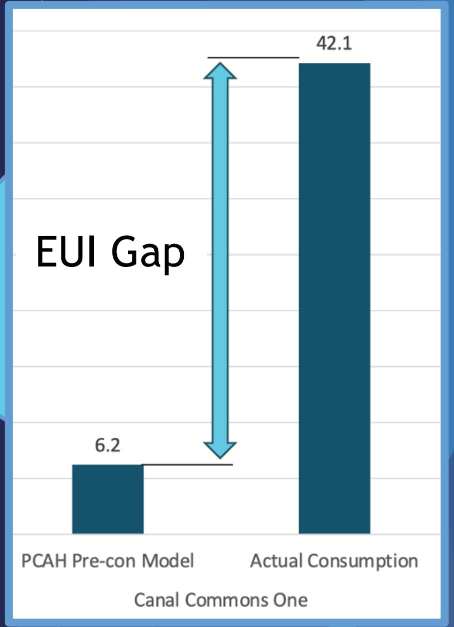
Natural Gas comparison

Calibrated Energy Model EUI Gap

Calibration helped to identify a rough breakdown of the EUI gap (actual vs. predicted)

- Would be more accurate if submetering data was available

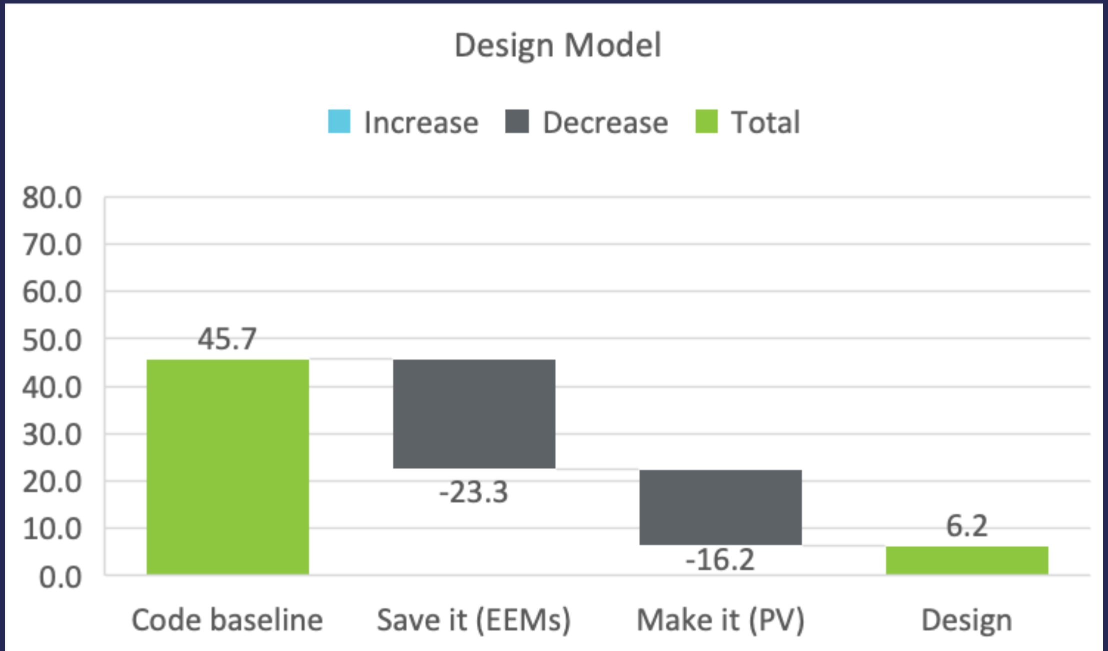




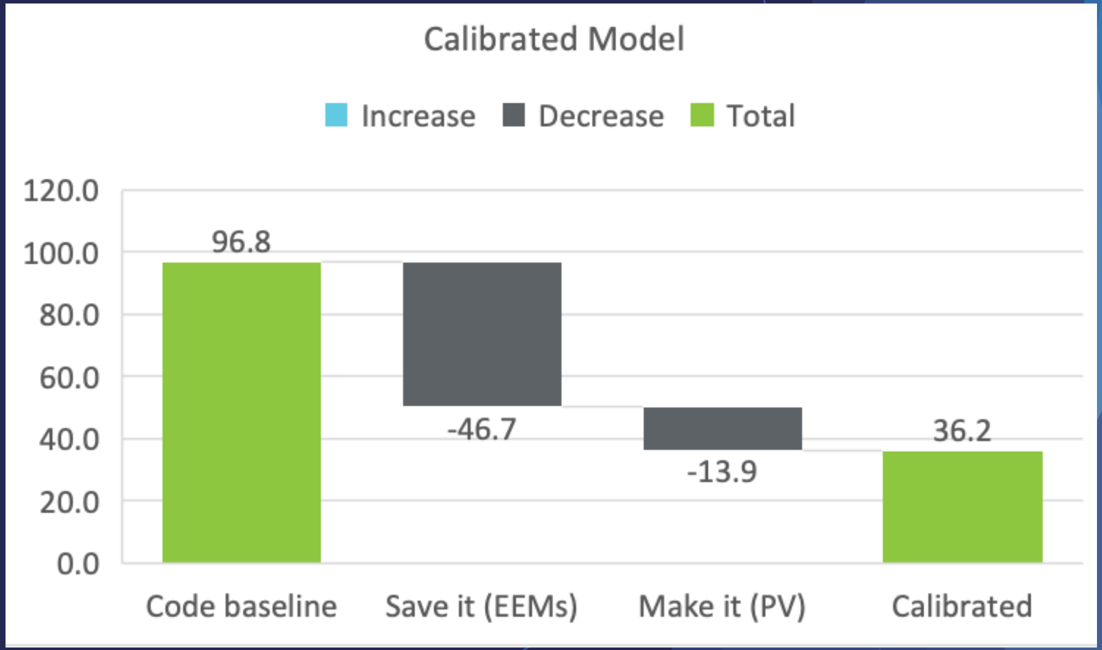
Updated Energy Savings Comparison

- Baseline energy was much higher in calibrated model than the pre-construction model.
- EEM savings increased since they were determined from a higher baseline.

Pre-construction energy model



Calibrated energy model



* Calibrated EUI of 36.2 does not include open windows in updated savings estimates.

Goal #2: Evaluate the long-term investments for the three Pacific Crest projects

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

The updated analysis showed a slightly longer payback, driven primarily by higher incremental costs for EEMs.

Original Break-Even = 5 Years

Updated Break-Even = 8 Years

Goal #2: Evaluate the long-term investments for the three Pacific Crest projects

Energy Efficiency Measures

- Specific EEMs performed better in the updated analysis
  - LED lighting, reduced infiltration, solar thermal hot water, VRF system
- Would compare alternatives to the central VRF system and evaluate tradeoffs in terms of cost, complexity, and resilience.

Every project is different and will have different measures that perform best in terms of payback.

Goal #2: Evaluate the long-term investments for the three Pacific Crest projects

Solar PV

- With incentives, the total cost to make an additional kWh of energy was much less than the total cost to save an additional kWh of energy.

Updated Canal Commons One Make vs. Save comparison:

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

Solar PV meets roughly 40% of total building electricity needs

- Projects need EEMs to get to zero energy

Resident Listening Session

Listening session with 12 residents, research team members, building architect, Energy Trust

- Keep health, safety, and comfort at the center of decision-making
- Feedback on specific systems
- Focus on resilience

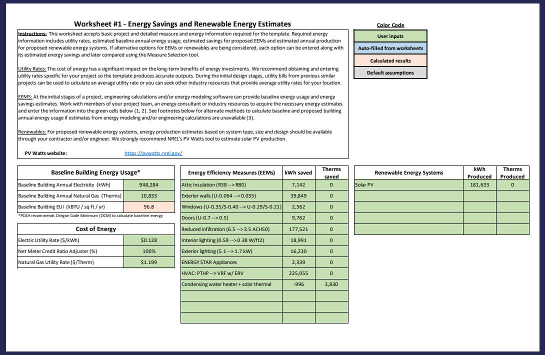
Goal #3: Develop guidance and resources for others seeking to evaluate energy performance investments over the lifespan of their projects

Make It & Save It Template

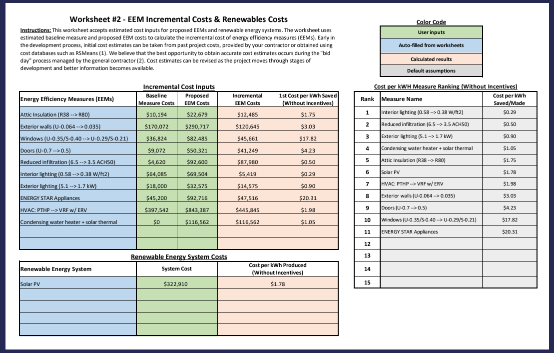
✦ Available now on the Energy Trust website

Workflow

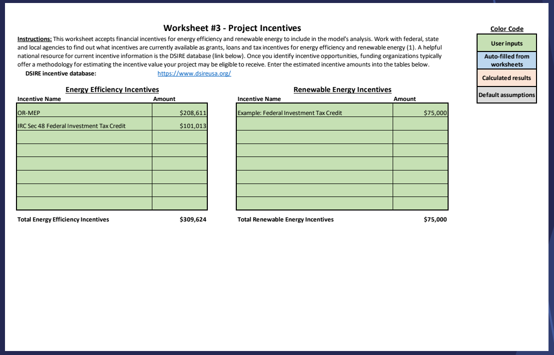
Energy Worksheet



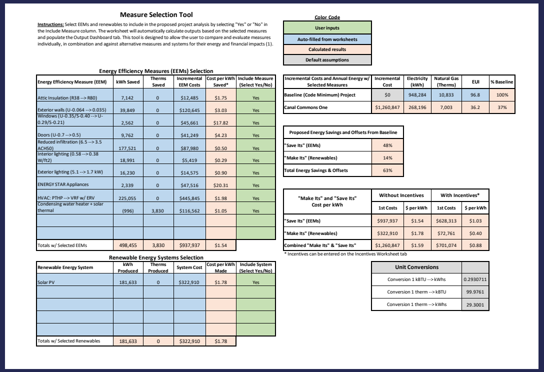
Cost Worksheet



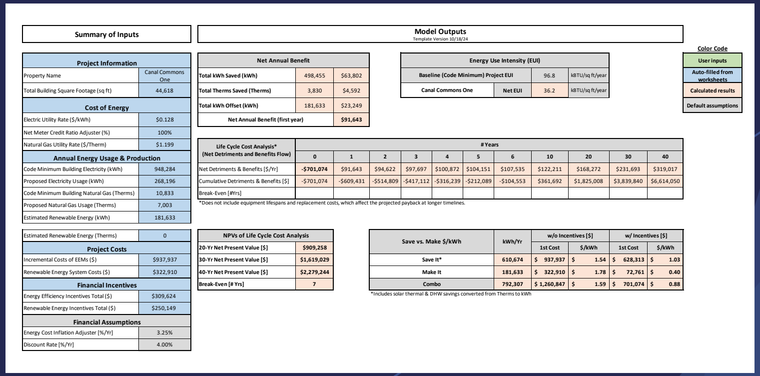
Incentives Worksheet



Measure Selection Tool



Output Dashboard



5. Recommendations

Recommendations for project design

Consider solar PV from the outset of a project

- Site selection, building orientation and available roof space.
- Maximizing available incentives makes solar PV much less expensive.

Energy efficiency measures

- Find clear winners and focus on implementing those top measures.
- Post-construction verification activities can help ensure successful construction outcomes.

Recommendations for project design

Iterative approach

- Exhaustive whole building energy modeling may be impractical for each development but specific lessons can be learned and applied with each successive project.
- Lessons learned should be incorporated into the next project, resulting in improved outcomes over time.
- A consistent team supports learning over multiple development cycles.
- Ensure all team members are on the same page.

Recommendations for specific measures

- Systems that communicate and provide alerts when they are not working support optimal building function.
- Operable windows: consider adding an interlock that turns off the HVAC if it’s open.
- 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.
- Higher-rated air filters during wildfire season can add cost and potentially reduce mechanical efficiency but provide health, comfort and safety benefits.

Recommendations for energy estimates

- Energy modelers should consider using more conservative assumptions in pre-construction energy models that assume more usage of the building and systems by occupants.
  - Plug loads: 0.75 W/ft^2 (instead of 0.5)

- Developers should be educated consumers of energy modeling.
  - Models may differ depending on the purpose. Determine the purpose(s) of energy modeling up-front.
  - Communicate with energy modeler. Ask questions!

Recommendations for cost estimates

- Consider adopting a “Bid Day” project delivery method, also known as a CMGC Project Delivery method.
  - Baseline cost measures and as-designed cost measures can be requirements of the subcontractors’ bids.

- More integrated work between energy modeler and cost estimator can ensure cost and energy estimates are aligned.

Recommendations for building operators

- For Multifamily properties that are master metered, consider ways to increase resident awareness of energy use and incentive to reduce consumption.
- Embrace operational oversight to help identify issues and reduce response time.
- Ensure that energy monitoring systems are working as designed.
- Optimize performance of all systems by training maintenance staff routinely.
- Consider purchasing longer subscriptions, extended system warranties, and annual service contracts from installing contractors.

Recommendations for further research:

- Prioritize submetering to gain further insight into the end uses driving higher-than-predicted energy consumption.
- Evaluate battery storage for existing solar PV systems to support resilience, reduce peak energy demand, and maximize solar PV benefits.

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Questions? Let us know!

Email contact:

Rob Roy robroy@pacificcrestgroup.org
Ben Bergantz benbergantz@pacificcrestgroup.org
Greg Collins gcollins@zeroenvy.com