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

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Pacific Crest Affordable Housing

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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

1. Introduction

Pacific Crest Affordable Housing

- For-profit developer based in Bend, OR building affordable housing since 2005
- Eight completed affordable multifamily apartment properties, 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

Rob Roy, Founding Partner & Co-Operating Manager, PCAH

- 23 years of experience in construction and real estate development in Oregon
- 18 years previous experience in the field in Canada
- 3-time Olympic snowboard coach for both USA and Canada

2002 Winter Olympics, Salt Lake City

2. Pacific Crest Approach to Sustainability

Pacific Crest Affordable Housing

Mission Statement:

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 to Sustainability

Need to justify dollars spent on energy performance through projected energy cost savings…

..by aiming to optimize investments and maximize value…

…by remaining a long-term owner, helping to ensure that the projects maintain financial sustainability by keeping operating costs lower.

Need to make project decisions in real-time, often under the constraints of budget, time and information.

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


Canal Commons One 148 kW Solar PV


Azimuth 315 107 kW Solar PV

Sustainability Beyond Energy

Pacific Crest Lavender & Honey

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

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

Spreadsheet developed between 2013 and 2015 as an in-house tool to evaluate proposed energy investments and guide decision-making.

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

Progressively Larger Solar PV Systems

Mountain Laurel Lodge
54 Units - Bend, OR

Discovery Park Lodge
53 Units - Bend, OR

Little Deschutes Lodge 1
26 Units - La Pine, OR

Little Deschutes Lodge 2
26 Units - La Pine, OR

★ First Spreadsheet ★

IronHorse Lodge
26 Units - Prineville, OR

Azimuth 315
50 Units - Bend, OR

Canal Commons One & Two
96 Units - Bend, OR

2006
18.3 kW Solar PV

2009
14.9 kW Solar PV

2010
24.0 kW Solar PV

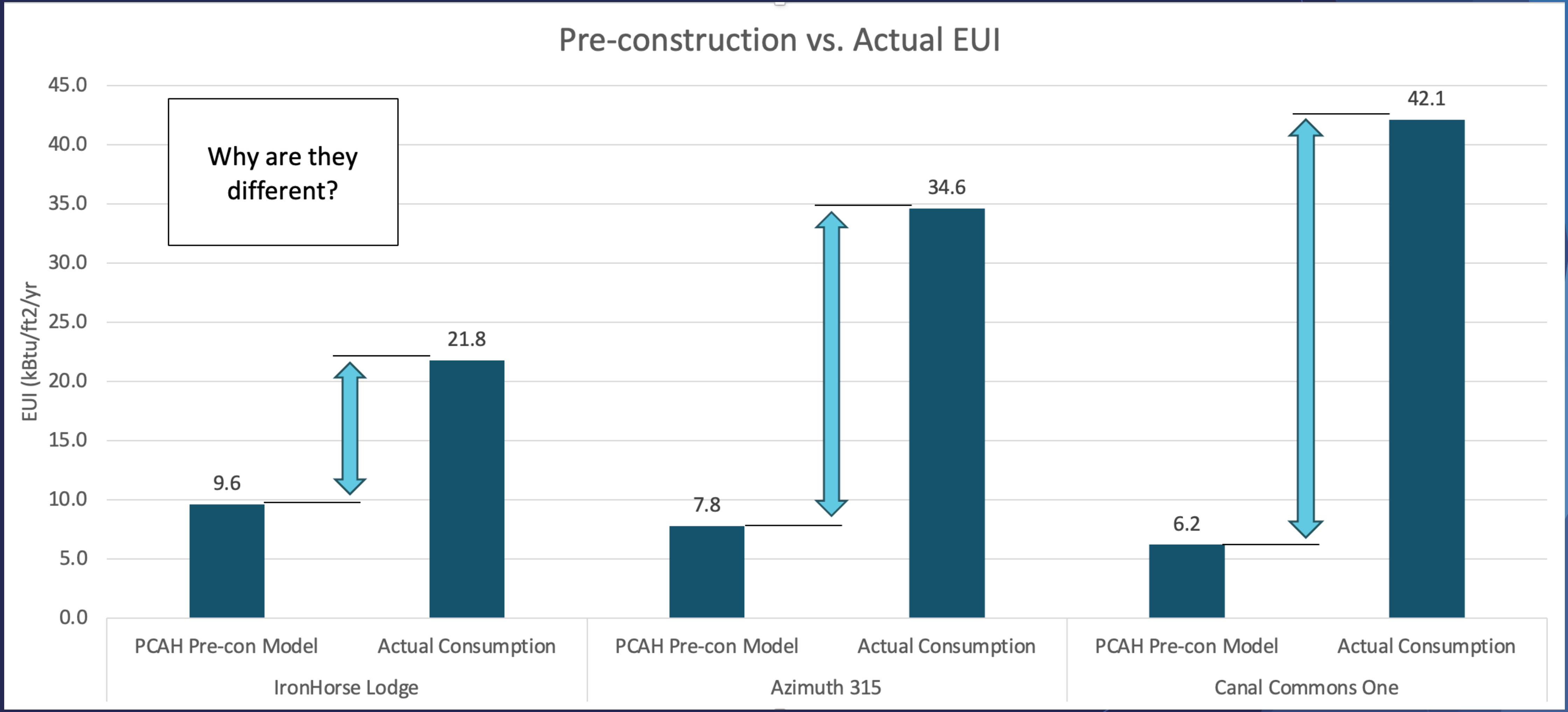
2013
32.2 kW Solar PV

2016
64.09 kW Solar PV

2019
107.52 kW Solar PV

2021 / 2023
297.39 kW Solar PV

Predicted Energy Use vs. Actual Energy Use



3. Research Goals & Methods

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.

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

IronHorse Lodge

Senior 55+

26 units: 1- and 2-bedrooms

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 (3.4 ACH50)

Certified Earth Advantage Platinum

Azimuth 315

Workforce & Family

50 Units: 1- and 2-bedrooms

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 (3.5 ACH50)

Certified Earth Advantage Platinum

Canal Commons One

Workforce & Family

48 Units: 1-, 2- and 3-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

“Why is energy use so much higher than predicted?”

Are the solar PV systems working as designed?

- Review solar production data

Pre-construction energy models overly optimistic?

- Questions about energy modeling results

Energy efficiency measures underperforming?

- Can be difficult to assess post-construction

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

Research methods:

- Gather and review measured energy data to quantify performance
- Conduct calibrated energy modeling based on measured energy usage and other available data to validate the actual savings of the project's energy efficiency measures.
  - Electric and natural gas
  - Solar PV production
  - Mitsubishi VRF submeter for central HVAC system
  - Leviton submeter for in-unit electrical demand (appliances & plug loads)
  - Onsite staff observations

Research Goal #2: Evaluate which measures and systems were the best long-term investments.

Research methods:

- Update Pacific Crest's financial models with the calibrated modeling results and updated incremental costs and utility costs to re-evaluate investments in energy performance.
- Hold a resident listening session to incorporate resident feedback and perspectives
- Incorporate factors beyond energy savings such as resilience, operations and maintenance, and the ability to monitor and measure system performance into measure and system evaluation

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

Research methods:

- Through the process of updating the financial models, evaluate the strengths and weaknesses of the PCAH spreadsheet as a tool and as an approach
- Adapt the spreadsheet to a user-friendly format and incorporate peer review feedback into a template to be available on the Energy Trust website

NPVs of Energy Savings
OR Code Minimum vs Canal Commons One
Original (Pre-Construction) Version

Assumptions		Comments
Energy Savings [kWh/SF/Yr]	11.58	Compared to OR Code Min Multifamily Bldg
Energy Cost Inflation Adjuster [%/Yr]	3.25%	CAGR 10-Yr Historical Analysis
Energy Cost 1st Yr [$/kWh]	0.145	Pacific Power OR Schedule 28 (No Facilities Charge)
Gross Building Square Footage [SF]	44,916	CCS1 Design Development Square Footage
Discount Rate [%/Yr]	4.00%	Market Driven
EEMs* 1st Costs w/o Incentives[$]	473,660	LIWP Worksheet Plus Additional EEMs (ETO-PTNZ*)
EEMs Incentive Amount	208,000	OHCS-LIWP **Loan**
EEMs 1st Costs w /Incentives	265,660	Calculated Intermediate Result
Renewables** 1st Costs w/o Incentives [$]	439,472	Actual$ PV-150kW Plus Thermal 20-24 Panel
Renewables Incentive Amount [$]	334,105	ETO-Solar PV,ODOE-Solar PV & ODOE Solar Thermal (Pre-Tax)
Renewables 1st Costs w/ Incentives [$]	105,367	Calculated Intermediate Result
Total 1st Costs [$] w/o Incentives [$]	913,132	Calculated Final Result
Total 1st Costs [$] w/ Incentives [$]	371,027	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

1st Cost Renewables	
PV	322,910
Thermal	116,562
Total	**439,472**

Confirmed by E2 Solar
v 01.22.24

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)*	45.70	13.39	601,576
Canal Commons PCAH Bldg (CCS1)**	6.20	1.82	81,641
Energy Savings CCS1 vs OCM	39.50	11.58	519,934

* Typical OCM Multifamily EUI of 45.7 (Zero Code) Provided By ETO
** PTNZ Goal Based on Model-Projected CCS1 Multifamily EUI of 9.6 Energy Trust of Oregon

Conversion 1 kBTU --> kWhs
0.29307107

Detriments (-) & Benefits (+) Flow*	0	1	2	5	6	10	20	30	40
Net Detriments & Benefits [$/Yr]	(371,027)	75,390	77,841	85,679	88,464	100,537	138,429	190,602	262,439
Cumulative Detriments & Benefits [$]	(371,027)	(295,637)	(217,796)	31,236	119,700	503,257	1,707,053	3,364,554	5,646,758
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 [$] D&BF	945,800
30-Yr Net Present Value [$] D&BF	1,529,693
40-Yr Net Present Value [$] D&BF	2,072,818
Breakeven [# Yrs]	5

Save vs Make $/kWh	Save.Make kWh/Yr	w/o Incentives [$]		w/ Incentives [$]	
		1st Cost	$/kWh	1st Cost	$/kWh
Save It*	229,733	$ 473,660	$ 2.06	$ 265,660	**$ 1.16**
Make it**	290,201	$ 439,472	$ 1.51	$ 105,367	**$ 0.36**
Combo	519,934	$ 913,132	$ 1.76	$ 371,027	**$ 0.71**

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

Original spreadsheet

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 8/15/24

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

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
Breakeven [#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**
Breakeven [# 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

Color Code

User Inputs	**Calculated results**
Auto-filled From Worksheets	**Default assumptions**

User-friendly template

4. Research Results

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

Solar PV Performance

- Solar PV data (previous 12 months) showed performance in-line with pre-construction estimates; the systems were performing as designed

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*

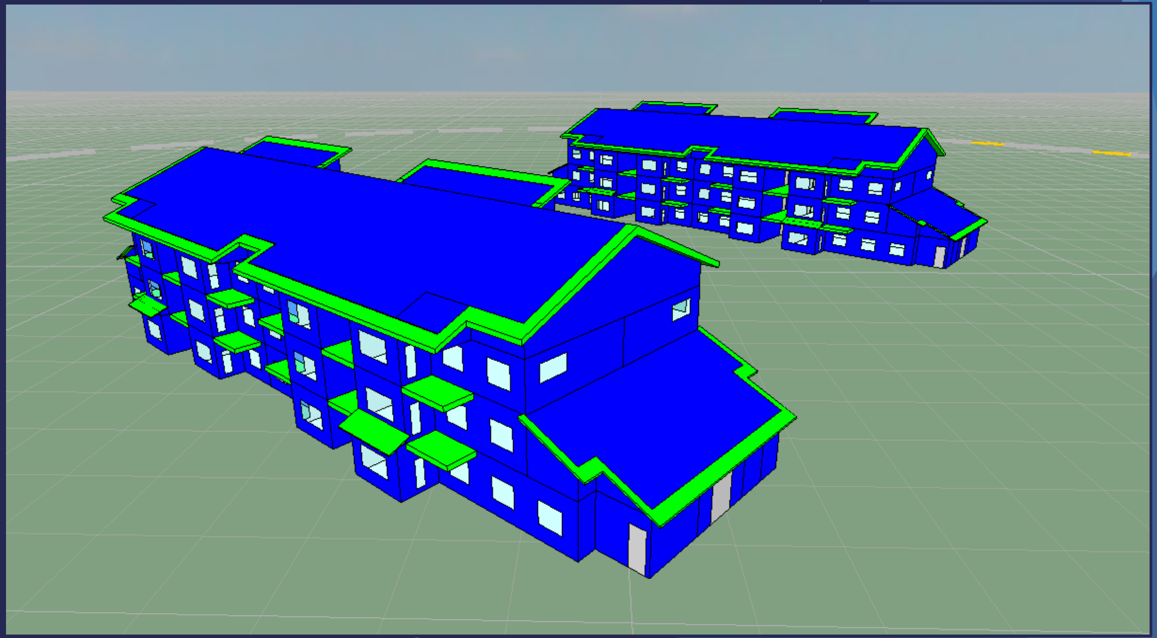
*Canal Commons One had a PV outage in 2023. The average annual solar PV production for the previous two years was 216,900 kWh per year (102% of PVWatts estimate).

Calibrated Energy Model Steps

1. Created a new energy model for Canal Commons One based on as-built design
   - Design drawings, submittals, etc.

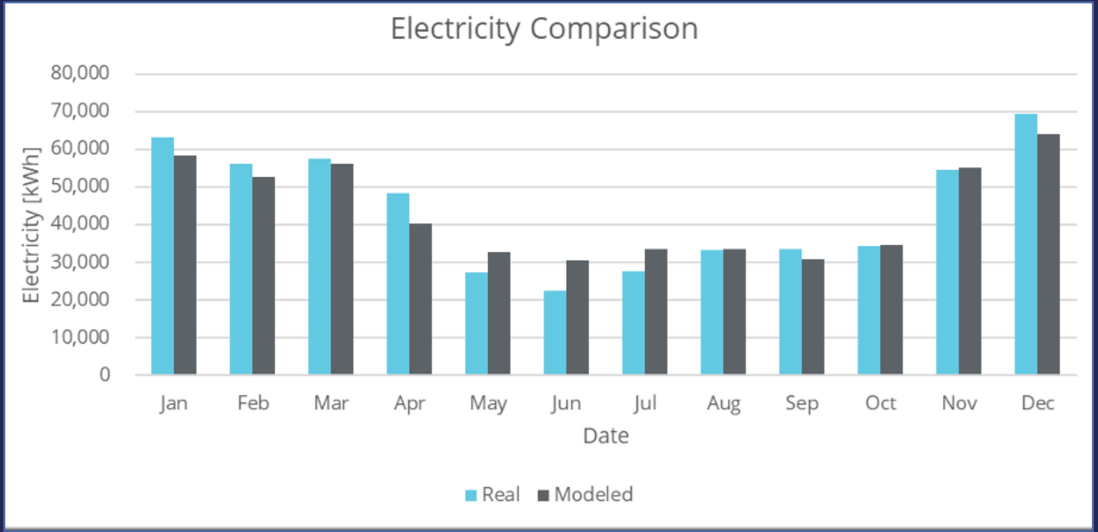
2. Collected & analyzed data
   - Utility bills + PV monitoring data
   - Submetering & VRF data was not usable
   - Onsite observations (confirmed open windows, no signs of mechanical issues or other issues)

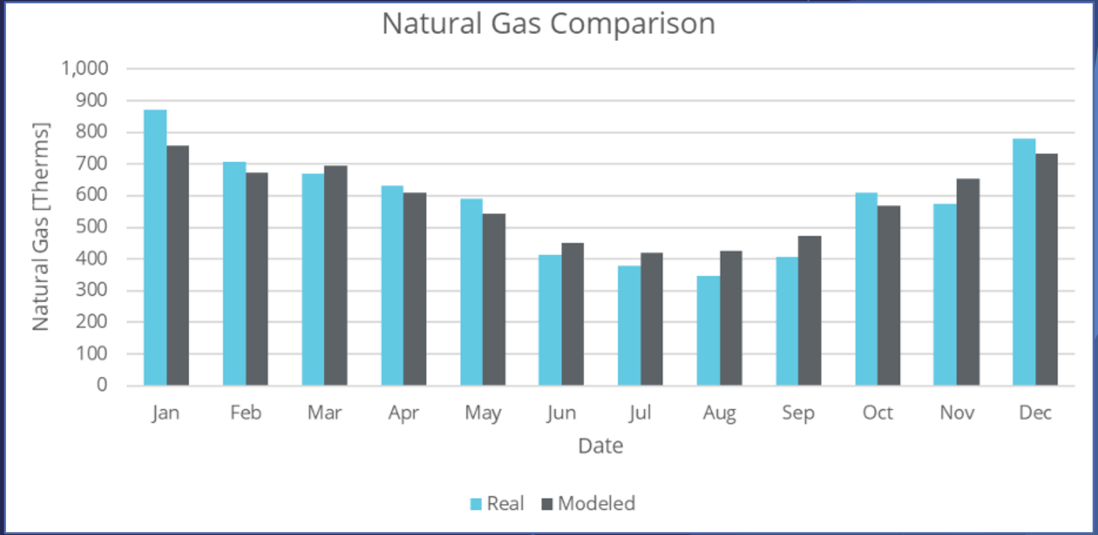
Image of the 3D energy model developed for Canal Commons One in IESVE software:



Calibrated Energy Model Steps

3. Model was calibrated to align with measured data
   - Actual weather file
   - Increased hot water usage, adj. incoming water temps
   - Temp setpoints, increased infiltration, increased plug loads, ***open windows***, and more



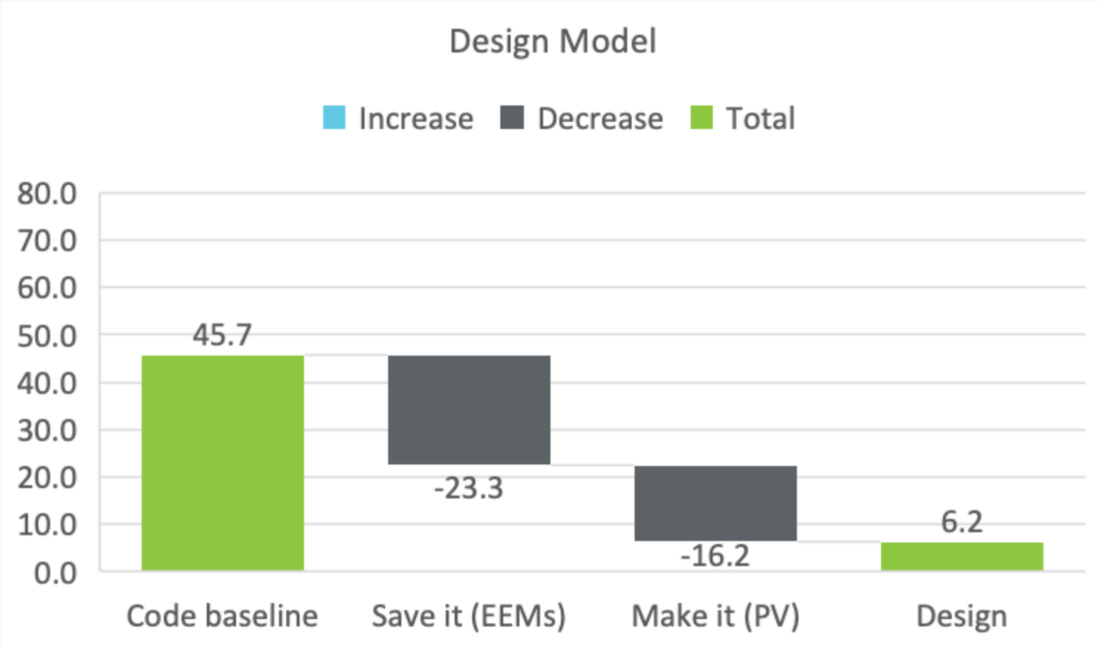


Calibrated energy model vs. actual energy consumption (electricity and natural gas)

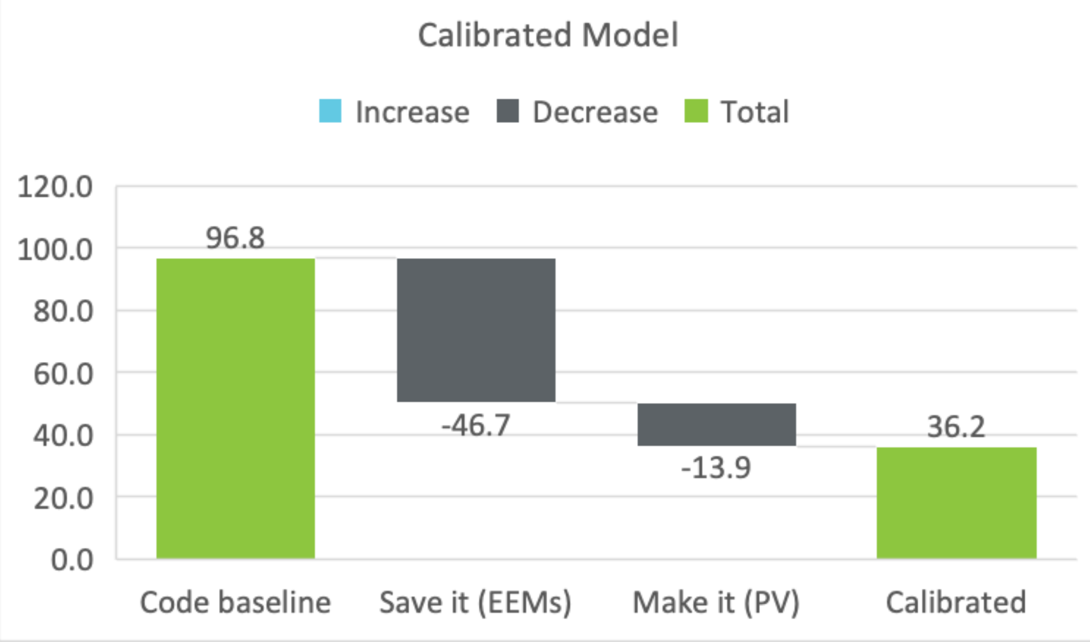
Updated Energy Savings Comparison

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

Pre-construction energy model



Calibrated energy model

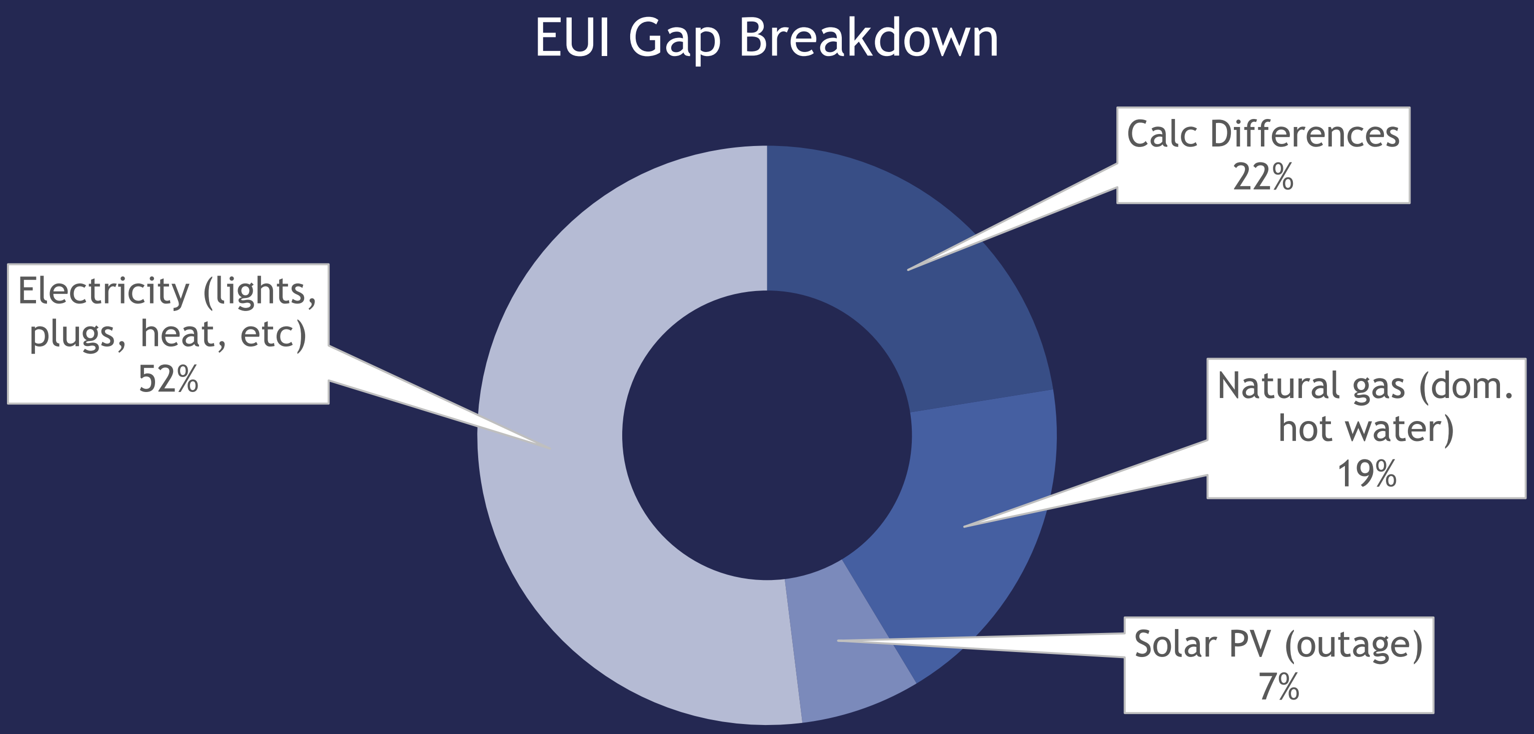


* Calibrated EUI of 36.2 does not include open windows in updated savings estimates.

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



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

Energy Efficiency Measures

- Specific EEMs performed better in the updated analysis:
  - LED lighting and controls
  - Reduced infiltration measures
  - Solar thermal hot water
  - Ductless Variable Refrigerant Flow (VRF) system with ERV
- Beyond the energy analysis, 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. Value is also influenced by construction costs, incentives, and utility costs.

Overall, the updated financial models showed that Pacific Crest's energy investments represented a good value

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

Original Break-Even = 5 Years

Updated Break-Even = 8 Years

Making The Case For Solar PV

With incentives factored into the analysis, the total cost to make an additional kWh of energy was much less on these projects than the total cost to save an additional kWh of energy.

- Solar incentives included Energy Trust Solar PV, ODOE-RED grant, Federal Investment Tax Credit, 100% Bonus Depreciation (federal and state)

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 non-energy benefits:

- Reliably predict solar PV production using PVWatts (within 5%)
- We know how much the system is producing and get alerted when there is an issue
- Protect against increases in the cost of electricity

Resident Listening Session

A listening session took place with 12 residents, research team members, building architect, Energy Trust

- Feedback on specific systems
  - Satisfied with hot water, lighting.
  - Central VRF system benefits from education
  - Information to residents—some interested in saving energy, some not interested
- Focus on resilience
  - Power outages
  - Wildfires
- Keep health, safety, and comfort at the center of decision-making

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

Evaluate and adapt the PCAH spreadsheet

- The research team assessed that the PCAH spreadsheet offered useful outputs when given accurate inputs.
- The team adapted the original into a user-friendly format and enlisted peer reviewers for feedback.
  - Not a perfect tool! Through the evaluation and peer review process, the team identified several areas for expanding and improving the tool that were ultimately not implemented due to research scope and timeline. The ”Make It & Save it” approach demonstrates a process for others to utilize that can be built upon in the future.

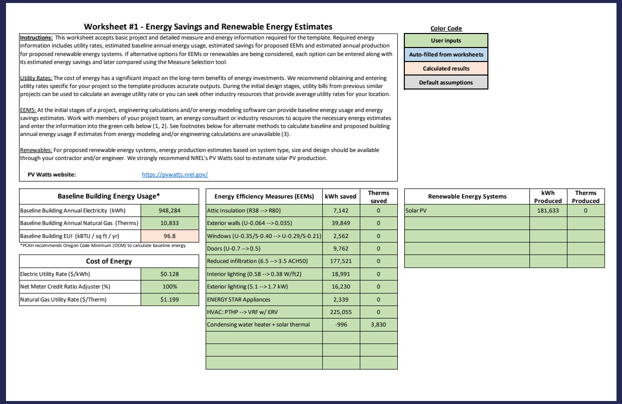
Key points:

- Design based on PCAH approach (master metered building, with net metering)
- Utility rates use average cost per kWh
- Life-Cycle Cost Analysis does not include equipment lifespans and replacement costs

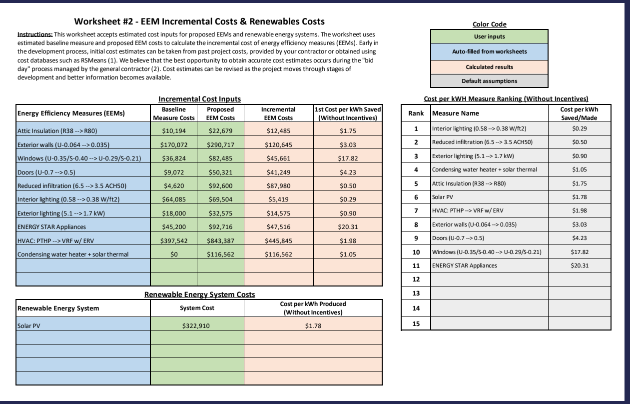
Make It & Save It Template

Workflow

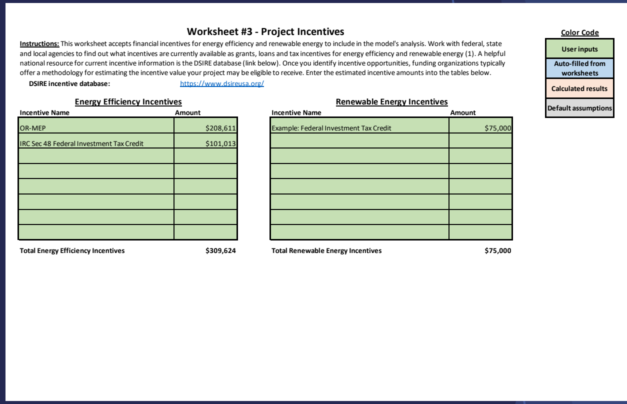
Energy Worksheet



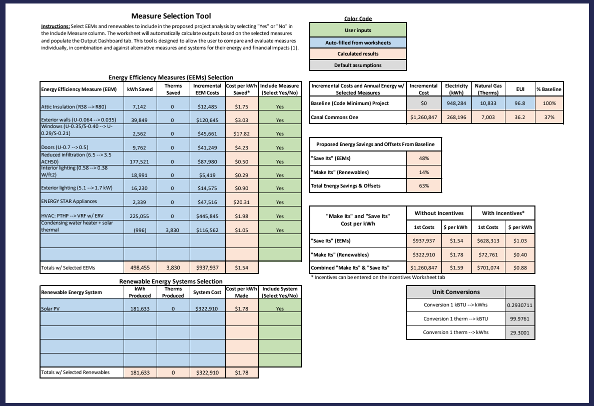
Cost Worksheet



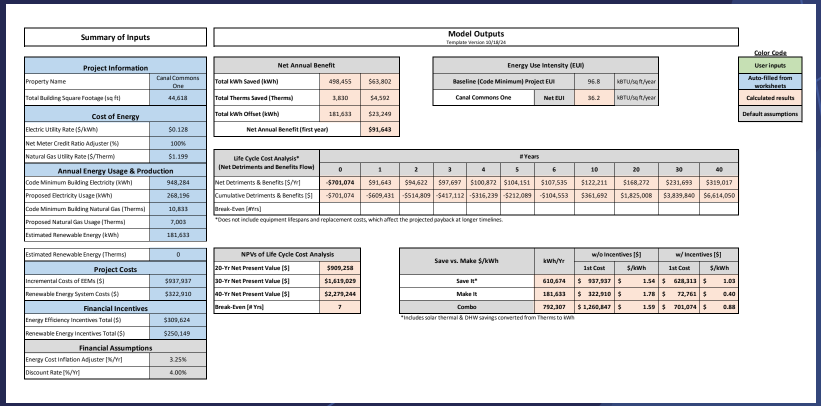
Incentives Worksheet



Measure Selection Tool



Output Dashboard



Considerations for using the template

There is inherent uncertainty in long-term projections. PCAH applied a rule of thumb that a project still needs to represent acceptable value at 80%.

Focus on the measures that are clear winners and implement those measures.

One method suggested by the Make It & Save It approach:

1. Solar PV should be prioritized from the start of a project, with initial site selection
2. Any energy efficiency measures that rate more highly than solar PV should be considered
3. Additional measures decided on case by case basis

5. Recommendations

Recommendations for project design

Consider solar PV from the start

- Site selection, building orientation, available roof space should all be taken into consideration
- Maximizing available incentives can make solar PV inexpensive from a project and developer standpoint

Energy Efficiency Measures

- The top EEMs are different for each project, find clear winners and focus on implementing them at scale
- Consider systems with the ability to self-monitor and communicate, or features that minimize dependence on the "human factor" for energy performance
- Post-construction verification activities, such as commissioning and blower-door testing, can help ensure successful construction outcomes and buildings that perform as designed

Recommendations for project design

Iterative design approach

- A consistent team of collaborators and subtrades supports learning over multiple projects
- Ensure all project team members are on the same page and aware of key energy design elements from the start
- Constraints of budget and timeline may mean exhaustive whole building modeling is impractical each development cycle but specific lessons can be learned and applied with each successive project
- Plan ahead of time in order to obtain accurate energy and incremental cost information for evaluating proposed investments

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; 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 of a system outage.
- 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 energy & cost estimates

- Determine purpose(s) of energy modeling up-front.
  - Incentive-focused model may not accurately predict EUI.
- When engaging an energy consultant, developers should proactively communicate around methods and purposes to increase the likelihood of obtaining useful modeling results.
  - Energy modelers bring different experience, tools, and methods.
- 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).
  - Plug loads: 0.75 W/ft^2 (instead of 0.5)

Recommendations for energy & 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. The “Bid Day” Bids are quite accurate and timely.
- We suggest you GOOGLE: CMGC Project Delivery Method
- 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 building operators

- Optimize performance of all systems by training maintenance staff routinely.
- Embrace operational oversight to help identify issues and reduce response time. Ensure that energy monitoring systems are working as designed.
- Consider purchasing longer subscriptions at the start of the service.
- Consider purchasing extended warranties on the systems.
- Consider purchasing annual service contracts from the installing contractor.
- For Multifamily properties that are master metered, consider ways to increase resident awareness of energy use and incentive to reduce consumption.
    - Provide feedback from submetering
    - Implement a reward system to encourage tenants to reduce energy use
    - Have tenants pay their own utility bills

Recommendations for further research:

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

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Questions? Let us know!

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