Residential Energy Efficiency Design Guide for Tribal Lands

Andrew Speake, Jes Brossman, and Jeff Maguire

National Renewable Energy Laboratory

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Executive Summary

Homeowners and renters on tribal lands have historically faced a disproportionate energy burden compared to the United States as a whole. The Indian Health Service (IHS), which serves these communities, strives to meet aggressive energy performance goals when constructing residential housing for their staff. Challenges common in rural locations, such as availability of materials, access to specialized labor, and budget constraints can hinder progress toward those goals. This guide is for architects and builders who aim to incorporate energy efficiency (EE) into their residential designs.

This report presents commercially viable energy efficiency packages across IHS's locations and a variety of design options to help guide home builders in choosing improvements for energy performance. The intention is to provide a diverse set of packages that can be used during the design phase to achieve energy savings compared to a code minimum building design. By presenting a set of diverse options with similar expected energy savings and life-cycle costs, final decisions can be left up to the building designers who can better determine the appropriate package given local costs, materials, and labor availability. Although this guide was developed for IHS projects, it can be used to help designers and construction professionals better make cost-effective choices when a detailed, project-specific building energy analysis is not possible.

Figure ES-1. Homes in remote areas, such as on rural native or tribal lands, represent a substantial opportunity for improved energy efficiency

New construction homes in the coastal village of Mertarvik, AK. Photo from Molly Rettig, NREL 68960

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List of Acronyms

ACH50	Air changes per hour at 50 Pascals of pressure
AFUE	Annual fuel utilization efficiency
EE	Energy efficiency
HSPF	Heating seasonal performance factor
HVAC	Heating, ventilating, and air-conditioning
IECC	International Energy Conservation Code
IHS	Indian Health Service
kWdc	Kilowatt direct current
kWh	Kilowatt hour
MMBtu	Million British thermal unit
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
SAM	System Advisor Model
SEER	Seasonal energy efficiency ratio
SHGC	Solar heat gain coefficient
SIP	Structural insulated panels
UEF	Uniform Energy Factor

1 Introduction

Remote residential housing projects, specifically those in rural tribal lands in the United States, often have higher energy burdens and inequitable ability to meet basic energy needs (Garza 2022). Reasons for this include material and equipment sourcing challenges, skilled labor shortages, and lack of clarity around how to improve energy efficiency. Most residential projects do not undergo energy modeling in the design phase, and therefore it can be difficult to identify what measures can be taken to cost-effectively improve energy performance upfront.

This report provides a framework for accounting for the incremental, upfront, and lifetime energy costs of residential designs, which builders can use to introduce energy-efficient measures into their designs. We performed energy efficiency cost optimizations for locations in which the Indian Health Service (IHS) operates, spanning International Energy Conservation Code (IECC) climate zones 2–8. To make the results more broadly applicable, we present five different cost optimal and near-optimal energy efficiency packages that can be selected based on project-specific details in the building design phase. Further, we have also estimated the technical potential for rooftop solar and solar hot water systems in each scenario, as well as the potential for improved energy resiliency under extreme weather for two of the cases: a heat wave in climate zone 2B and a polar vortex in climate zone 7A. This report is organized as follows: Section 2 presents background information on the IHS and relevant building codes, Section 3 describes an overview of the methodology and how we decided on the different energy efficiency packages, and Section 4 presents a brief explanation on how to use the package information and recommendations in Section 5. Section 6 provides results from the energy resilience study, and Section 7 concludes the report.

Figure 1. Thoughtful home designs on tribal lands have long provided shelter adapted to regional climates. The Anasazi Cliff Dwellings were built into depressions in cliffs providing shelter and comfort across seasons.
Photo by John Thornton, NREL 03544

2 Background

The IHS is a federal agency that provides health services to all federally recognized American Indian Tribes and Alaska Natives, with health care facilities in 12 distinct areas (Figure 2) that span 574 federally recognized tribes in 37 states[1]. The services provided by IHS include providing housing for medical personnel staffing their facilities. Given the remoteness and diversity of climate among IHS regions, effectively meeting energy performance goals for these small residential projects can be challenging.

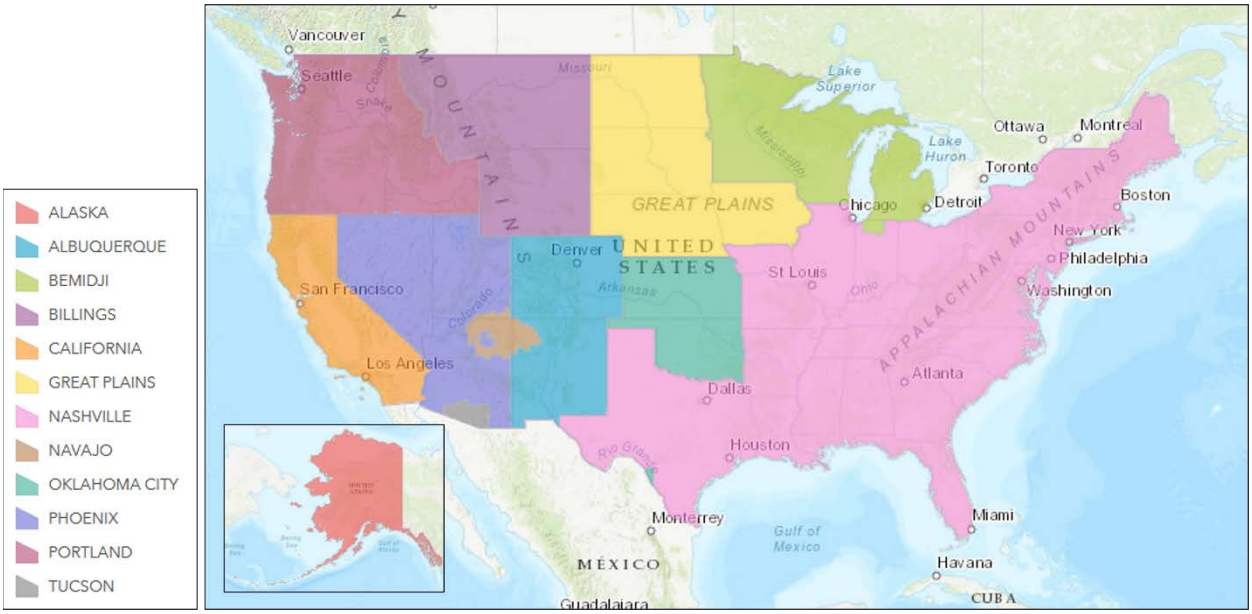


Figure 2. Map of the 12 IHS areas

Map from the IHS

This report is intended to reduce the burden on designers and builders in determining cost-effective efficiency measures in residential new construction projects. During the design phase builders can leverage the recommendations in this report to budget above-code efficiency packages. This report is not meant to be prescriptive; however, we hope that these region-specific analyses can help builders make decisions based on local costs and labor constraints to determine which packages is most suitable for them to build.

[1] https://www.ihs.gov/

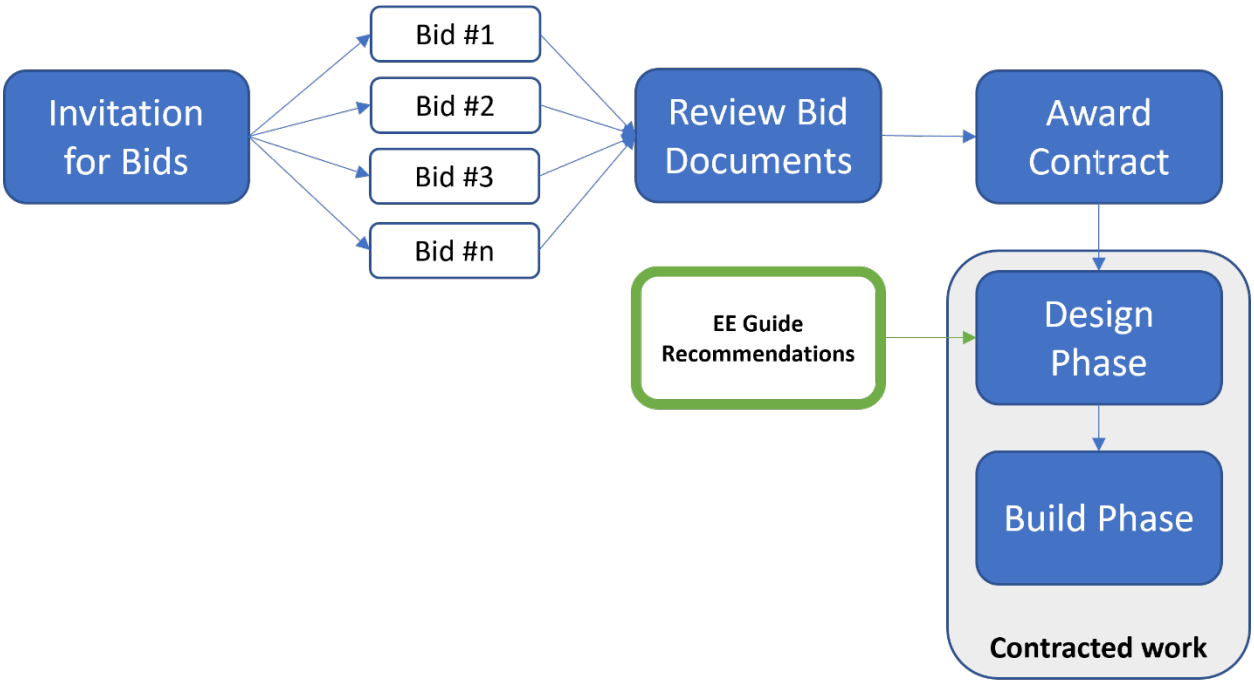


Figure 3. This guide can be incorporated into the design phase of a typical IHS residential construction project.

2.1 Relevant Energy Codes and Standards

IHS adheres to all local building and energy codes in their residential projects, and, as a federal agency, they have adopted more aggressive goals in the pursuit of sustainable buildings. IHS has adopted the *Guiding Principles for Sustainable Federal Buildings* as part of their building design procedures (Council on Environmental Quality 2020). That guide is published by the Council on Environmental Quality and lays out six principles with the intent of advancing sustainable building practices. This report provides information relevant to the second principle, Optimize Energy Performance, and the final principle, Assess and Consider Building Resilience. More specifically, we address the following criteria laid out for new construction and modernization projects: Criteria 2.1 – Energy Efficiency, Criteria 2.3 – Renewable Energy, and Criteria 6.2 – Building Resilience and Adaptation.

Criteria 2.1 – Energy Efficiency

This criterion requires the strategies that optimize energy performance and minimize energy use over the building lifetime. Within the Code of Federal Regulations, 10 CFR Part 435— "Energy Efficiency Standards for the Design and Construction of New Federal Low-Rise Residential Buildings" (Department of Energy 2022) — is the driving federal requirement of this criterion and was used to define energy performance constraints in our analysis. Following is a summary of items within 10 CFR Part 435 relevant to our study. Additional detailed discussion of building inputs can be found in Section 3.1.

- **Applies to**: New federal low-rise residential buildings
- **Baseline comparison**: IECC 2021[2]

[2] Local code levels may differ, but the cost and energy savings reported in this guide are based on the IECC 2021.

- **Energy improvement:** Energy consumption levels should be at least 30% below the IECC 2021 baseline
- **Exception:** If 30% energy consumption savings are not cost effective, the proposed building shall achieve an energy consumption level at or better than the life cycle cost-effective design.

Criteria 2.3 – Renewable Energy
This criterion directs designers to incorporate renewable electric or thermal strategies where possible to help federal agencies progress toward overall energy goals. In support of this, we analyze the potential for both rooftop solar and solar hot water systems, two of the options for incorporating renewable energy as laid out in the guiding principles that can apply to residential buildings. We explore the potential for these technologies to be applied to a high-performance building in each location, as discussed in Section 3.2.

Criteria 6.2 – Building Resilience and Adaptation
Finally, this criterion is designed to mitigate short- and long-term impacts associated with climate change and weather events. We provide context into the short-term energy resilience of two of the building designs subject to extreme temperatures, as discussed in Section 3.3.

3 General Methodology

We provide results from numerous analyses to recommend and analyze potential for energy efficiency, rooftop photovoltaics (PV), solar hot water, and energy resilience. We selected locations in which IHS already manages residential buildings and may have a possibility of similar housing construction projects in the future, which also provides diversity in climates to help apply more generally to similar construction projects. At least one location per climate zone in which IHS operates is modeled, and at least one location per IHS area is modeled. Figure 4 shows the 19 locations, depicted with a star, used for modeling overlayed on the IECC climate zone map.

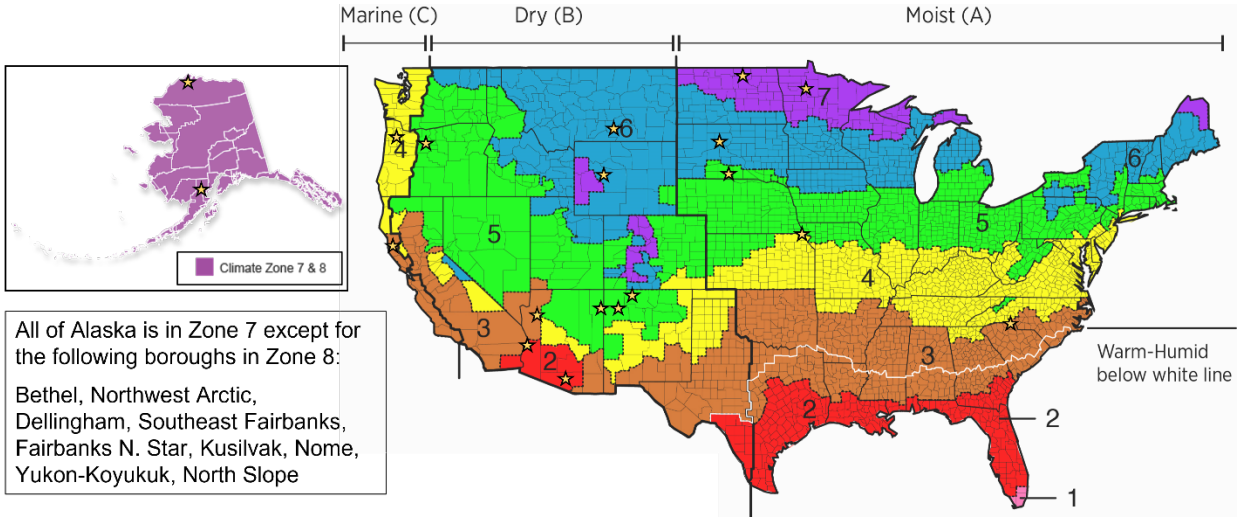


Figure 4. Map of IECC climate zones and building model locations

Map from Department of Energy

In general, the same prototypical home design was modeled in each location, with exceptions for differences in local energy code and construction practices. To account for resource availability, two different heating fuels were modeled for each location, which influences fuel types of heating, ventilating, and air-conditioning (HVAC) and water heating systems. Table A-1 lists each of the locations, heating fuels, and foundation types considered in the cost optimizations. Further details regarding the baseline and upgrade inputs are included in the following subsections.

3.1 Identifying Energy Efficiency Packages

This section provides a high-level discussion of the modeling process used to identify energy efficiency packages and is accompanied by a more detailed methodology in Appendix B.2. To meet the 10 CFR Part 435 standard for energy efficiency, we performed cost optimizations with whole-building energy modeling software to identify which efficiency packages for new construction duplexes are the most cost-effective over time. We used the National Renewable Energy Laboratory's (NREL's) Building Energy Optimization Tool, or BEopt™,[3] to determine the sets of cost-effective and commercially viable packages. Our methodology (Figure 5) starts with defining prototype inputs that are constant across all possible designs. With the prototype inputs defined, prescriptive IECC 2021 inputs and other location-specific inputs are applied to establish the baseline, and a set of potential upgrade options are selected that exceed this code minimum baseline. Every combination of upgrade options represents a potential building configuration, or package, which is simulated in BEopt to determine life cycle costs. From the set of packages and life cycle costs, a subset of packages with similar site energy savings can then be selected.

[3] For more information, see https://www.nrel.gov/buildings/beopt.html.

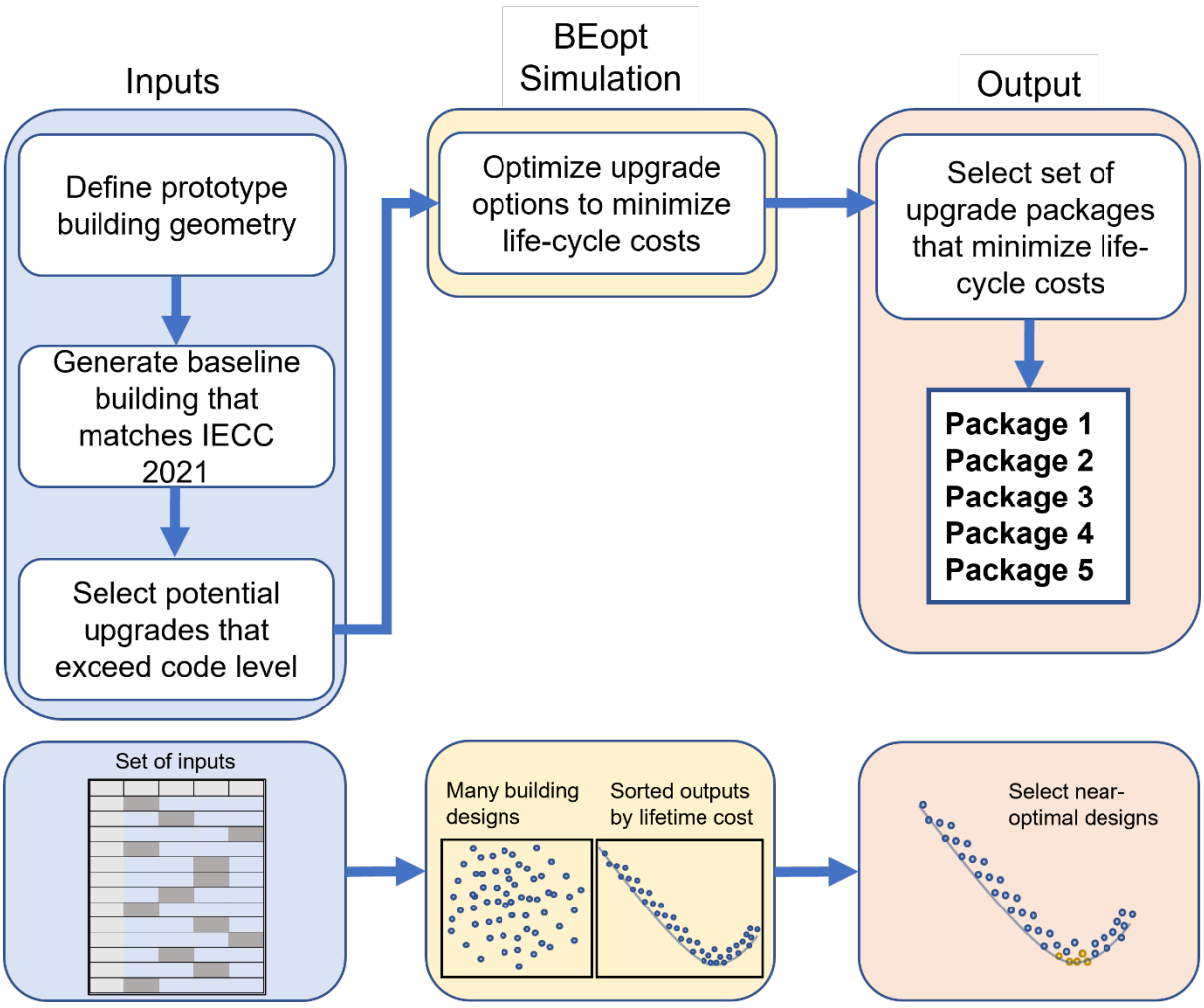


Figure 5. Flowchart of the methodology to determine cost-effective energy efficiency packages for a single location and fuel type. This approach is repeated for all cases presented in Section 5.

Prototype Inputs

The prototype building design is a one-story duplex with 1,400 ft^2 of living space per unit and one garage per unit, as shown in the BEopt design in Figure 6. A table of high-level model inputs that applies to all homes and locations is provided in Table 1. These inputs align with typical residential duplexes currently operated by IHS. Baseline envelope insulation inputs were sourced from the IECC 2021[4] (International Code Council 2021) to align with the *Guiding Principles for Sustainable Federal Buildings* discussed in Section 2.1. Inputs for air leakage, mechanical ventilation, and ducts were also sourced from the IECC 2021. To adhere to section R408.2 of the code, *Additional efficiency package options*, we located all ducts entirely within the building thermal envelope. Various other data sources informed the remaining inputs and are detailed in Table A-2 and Appendix B.1. Once baseline, code minimum homes were defined in each location, we explored above-code measures to determine potential cost-effective energy-efficiency improvements.

[4] Specifically, Table R402.1.3.

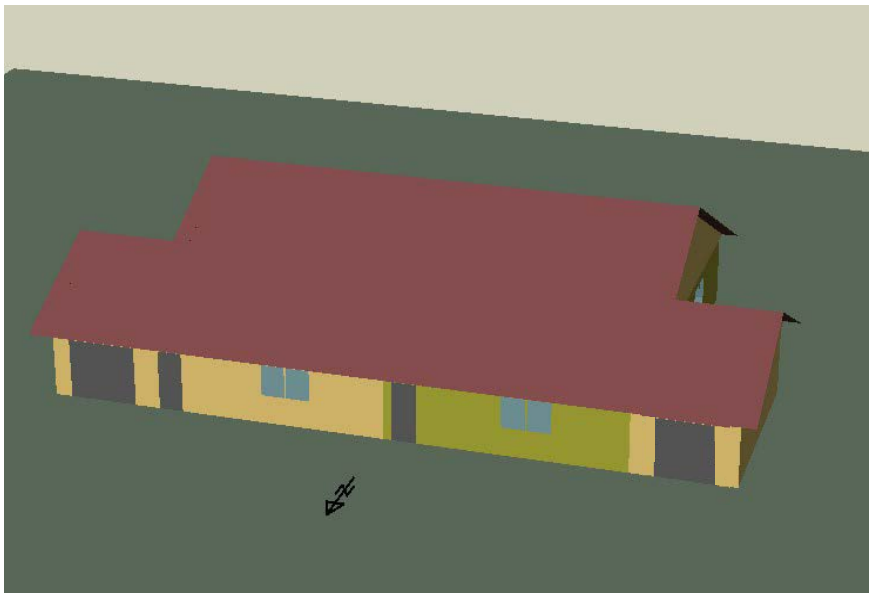


Figure 6. Prototypical duplex modeled in BEopt

Table 1. High-Level Baseline Inputs

Input	Value
Above-Grade Square Footage	1,400 ft^2/unit
Units	2
Above-Grade Stories[a]	1
Bedrooms	2/unit
Bathrooms	1/unit
Garage	1-car/unit
Wall Type	Wood frame[b]
Attic Type	Vented attic[c]
Foundation Type	Specified in Table A-1
Window To Wall Ratios	9% at each facade
Building Orientation	North
HVAC	Heating and cooling present[d]
Analysis Lifetime	40 years
Inflation Rate	2.4%

[a] Some locations include below-grade finished basements, which match footprint of above-grade space (Table A-1).
[b] Utqiagvik, AK cases have structural insulated panels (SIP).
[c] Utqiagvik, AK cases have finished roofs.
[d] Cooling is not present in Utqiagvik, AK.

Energy Efficiency Upgrade Options

In BEopt, potential improvements to the baseline models can be selected based on commercially available efficiency measures and engineering judgement. There is no limit to the number of upgrades that can be considered, and therefore, we included any upgrade that would be reasonably installed given the home design and local practices. This study considers energy performance improvements beyond the IECC 2021 in the areas of building envelope, mechanical equipment, lighting, and water heating, but excludes potential benefits from operational controls such as HVAC thermostat decisions. The cost optimizations consider numerous energy efficient envelope and equipment upgrades to identify pathways for energy performance improvement beyond the 2021 IECC. The various components considered for upgrade are detailed in Figure 7.

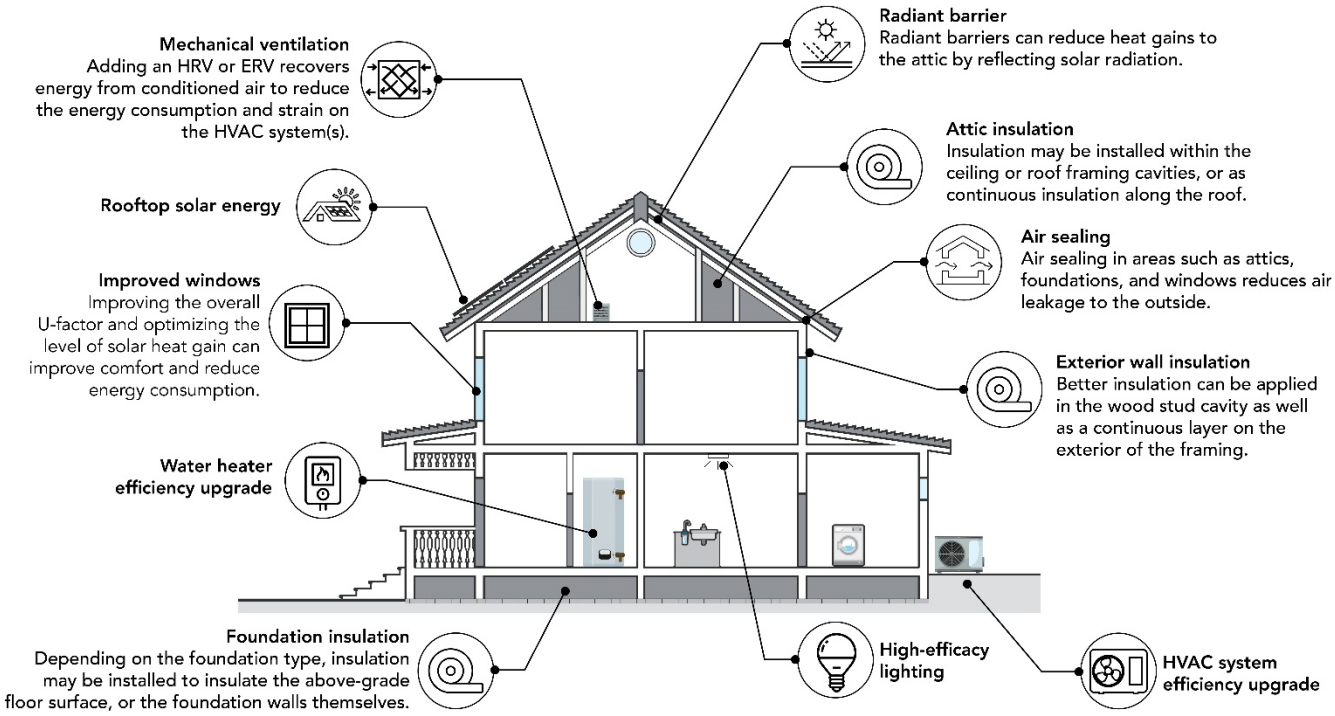


Figure 7. Upgrade options considered in the recommended energy efficient packages

Note: Not all upgrade options were deemed cost-effective in every scenario, but each were considered to some extent. Figure by Josh Bauer, NREL

Some efficiency improvements may have a variety of valid installation methods in practice. This is particularly true for envelope enhancements, where differences occur based on the builder, local codes, or architectural details. Our assumptions regarding envelope insulation installation are shown in Figure 8 –Figure 12, which describe assemblies for exterior walls, attics, and three foundation types. These methods for installation were chosen to align with the most common approaches, while avoiding overly specialized designs. The actual upgrades to each of these envelope components include varying levels of cavity and continuous insulation, which are specified in the recommendation tables in Section 5. The baseline assumption for wood stud walls were 2x4 thickness with 16” stud spacing, but we included both 2x4 and 2x6 thicknesses in the potential above-code designs. The figures below show assumptions for all locations except for Utqiagvik, Alaska, which has differing construction practices due to the more extreme

weather. Table 2 describes the assumptions used in the code minimum and upgrade scenarios in Utqiagvik, while Sections 5.37 and 5.38 provide the specific options chosen. Methods of reducing air leakage may also vary. This report does not assume specific air sealing techniques, but instead analyzes the cost benefit of varying levels of leakage. For more detailed directions towards the implementation of EE measures, refer to Appendix C.1.

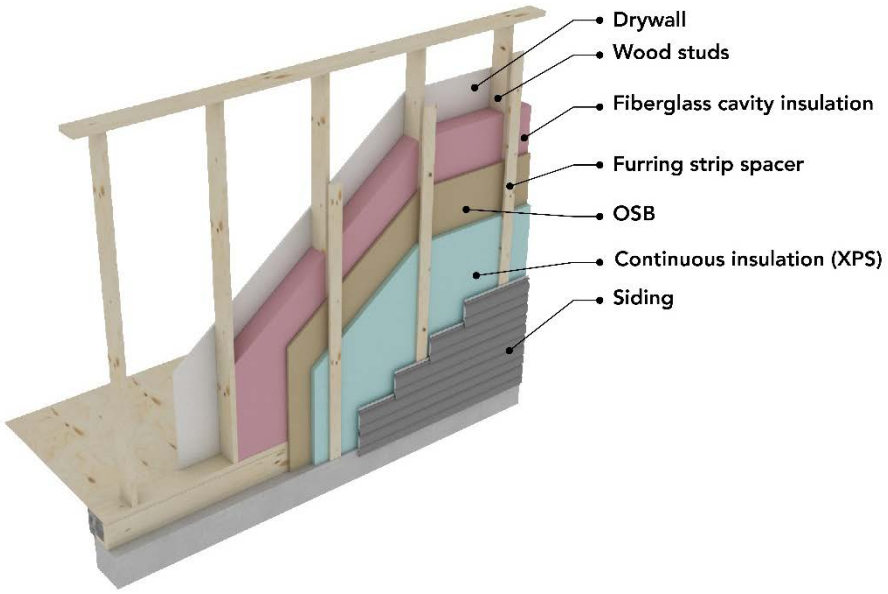


Figure 8. Exterior wood frame wall assembly: fiberglass batt insulation is installed in cavities and continuous XPS insulation on the exterior of the framing. Thickness of cavity insulation and continuous insulation may vary.
Only materials used in energy modeling are displayed, other layers may be required based on standard practices and local code. Figure by Josh Bauer, NREL

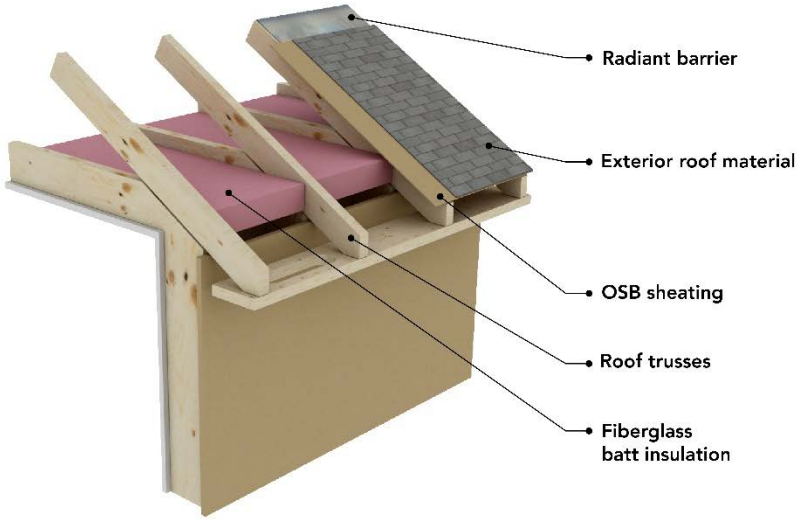


Figure 9. Vented attic assembly: fiberglass batt insulation is installed in the ceiling joists and a radiant barrier may be installed at the roof. The thickness of cavity insulation may vary.
Only materials used in energy modeling are displayed, other layers may be required based on standard practices and local code. Figure by Josh Bauer, NREL

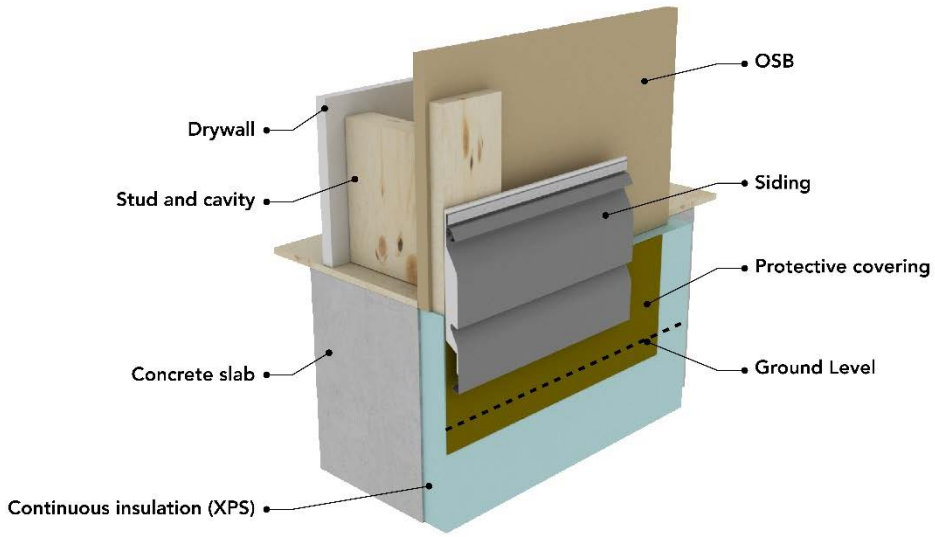


Figure 10. Slab foundation: continuous insulation installed to the perimeter of the slab. The depth and thickness of the insulation may vary.
Only materials used in energy modeling are displayed, other layers may be required based on standard practices and local code. Figure by Josh Bauer, NREL

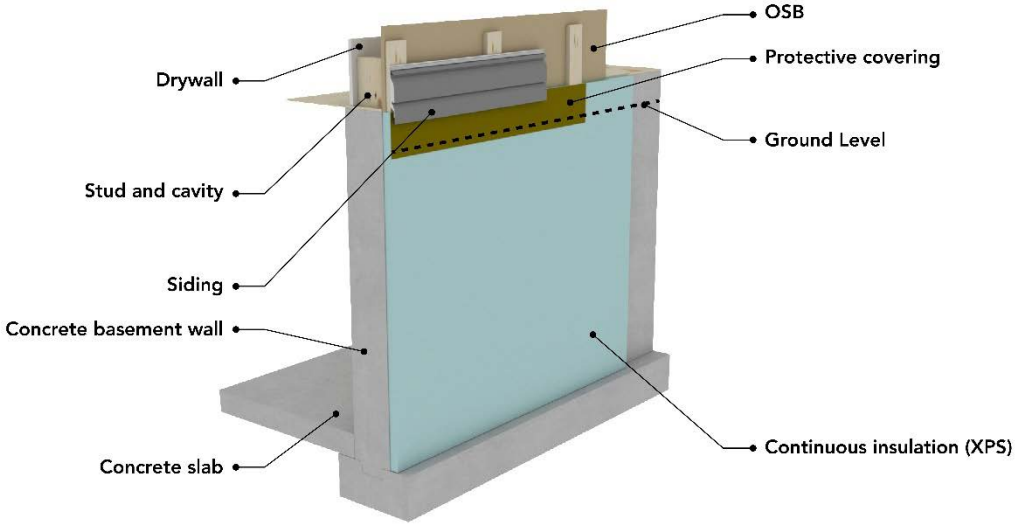


Figure 11. Finished basement foundation: continuous insulation installed to the perimeter of the finished basement walls. The thickness of insulation may vary.
Only materials used in energy modeling are displayed, other layers may be required based on standard practices and local code. Figure by Josh Bauer, NREL

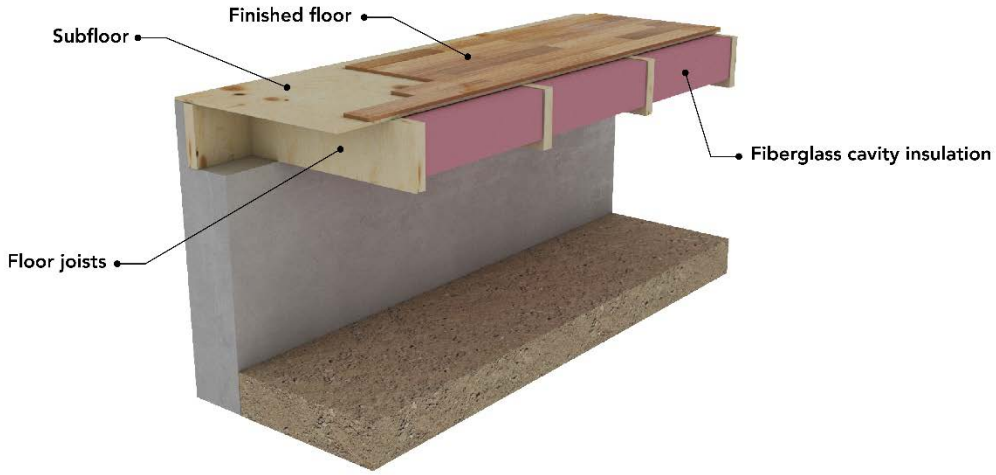


Figure 12. Crawlspace foundation: continuous insulation installed in the cavity of the floor joists.
Only materials used in energy modeling are displayed, other layers may be required based on standard practices and local code. Figure by Josh Bauer, NREL

Table 2. Specific envelope components for Utqiagvik, AK

Component	Description
Exterior Walls	Structural Insulated Panels (SIP) with varying thicknesses for upgrades
Attic	Batt insulation in the roof cavities with varying levels of continuous insulation on the outside of the roof trusses for upgrades
Foundation	Raised foundation with cavity insulation in the floor joists and varying levels of continuous insulation on the underside of the floor joists

Selecting and Reporting Packages

By simulating hundreds to thousands of potential combinations of efficiency packages, BEopt can exhaustively search for the package that provides the lowest lifetime cost. Cost assumptions for efficiency options in BEopt v2.8 are derived from the National Residential Efficiency Measures Database v3.1.0 . Costs of individual options determine the overall package costs, which are balanced against lifetime utility cost savings in the BEopt optimization algorithm. Because cost assumptions can vary greatly by region, we report five unique packages in each scenario. The energy efficiency packages that meet or exceed code minimum while delivering cost and energy savings are presented in Section 5. Each set of tables and figures in that section is for a specific location and heating fuel and shows location-specific assumptions. More details regarding the presentation of packages and the methodology driving their selection can be found in Section 4 and Appendix B.1, respectively.

3.2 Rooftop Photovoltaics and Solar Hot Water Technical Potential

For each location and heating fuel scenario, we analyzed the potential of a rooftop PV system and a solar hot water system applied to one EE package (Package 1). These preliminary PV analyses were not considered as a measure in the EE package selection, but instead were singular runs applied to the lowest cost package. NREL's System Advisor Model (SAM)[5] enabled simulation of fixed roof mount PV installations with the PVWatts (Dobos 2014) model. Table 3 provides key inputs assumed for each PV model. To account for snow cover in colder climates, we relied on annual loss factors published in a study by the SAM team (Ryberg and Freeman 2017), Table A-3. Other losses incorporated into the model include soiling, shading, current-voltage mismatch, wiring, connections, light-induced degradation, nameplate rating, and operational availability.

Table 3. High-Level Inputs for Rooftop PV Analysis[ab]

Input	Value
Available roof area	1,227 ft²
System size[c]	6.5 kWdc
Inverter efficiency	96%
Total system losses[de]	14.1%
Snow cover losses	Table A-3
Annual degradation rate	0.5%/yr
Azimuth	180° (South)
Tilt	26.6° (roof pitch)
Billing mechanism	With and without net metering (2 runs)

[a] Default inputs from PVWatts were used if not specified in this table (Dobos 2014).
[b] These are assumptions used in modeling software, actual system inputs will likely differ
[c] Based on 80% of the south facing roof
[d] Does not include local losses due to snow cover.
[e] Further breakdown of system losses are found in Dobos (2014).

Given the complexity and unique location-specific grid policy that informs the underlying economics of residential PV systems, our analysis focuses primarily on the technical potential of the system and does not constitute a full PV cost analysis. We output plots showing monthly PV generation and electric loads as well as average 24-hour profiles of generation and electric load for a month in the summer, a month in the winter, and over an entire year to demonstrate the seasonal nature of PV generation (Figure 13). We output cost savings from two billing scenarios, one with net metering, in which all excess generation is purchased back at the sell rate of the utility, and one without net metering, in which excess generation is not sold back at all. By analyzing PV with both billing scenarios, we set preliminary bounds on the expected cost savings of the system. In addition, we used BEopt to simulate solar water heating, also applied to the lowest cost option (Package 1). A 40ft^2 collector is assumed for each unit, with a heat exchanger effectiveness of 0.70.

[5] For more information, see https://sam.nrel.gov/.

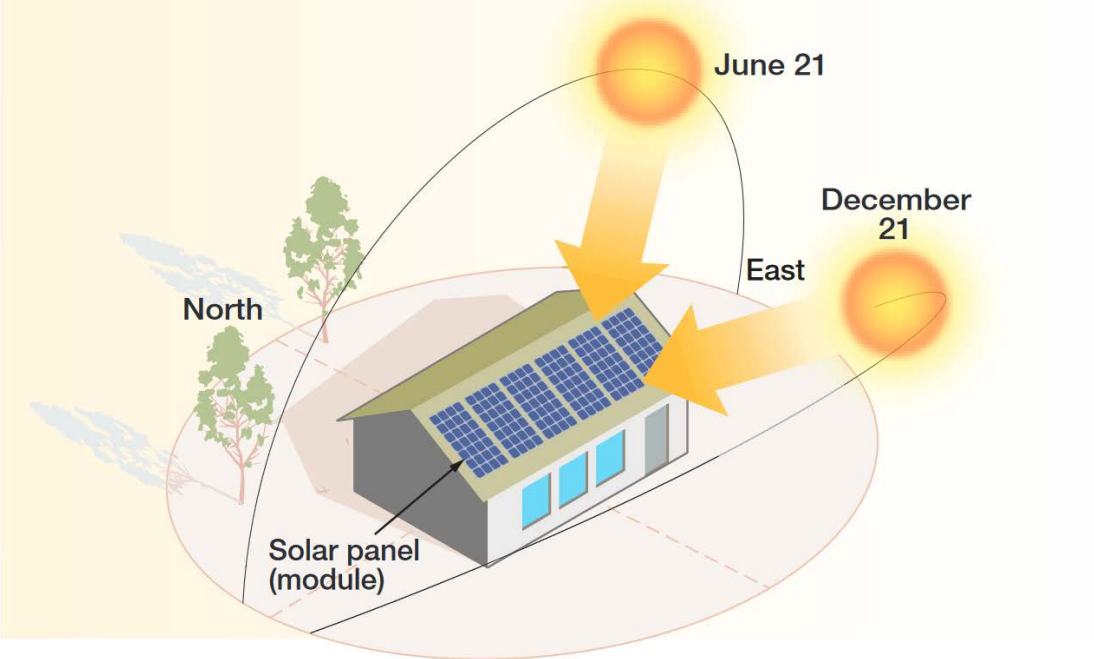


Figure 13. PV generation is impacted by many factors that are specific to the home. The angle of the sun based on latitude or time of year is one contributor, but also site-specific attributes such as shading, roof pitch, and orientation, which can be modeled using commercially available software tools (Appendix C.2.).

Image from NREL, https://www.nrel.gov/docs/fy09osti/43844.pdf, page 7.

In practice, PV generation depends on many factors specific to the building that may not align with our assumptions, further, the local economics of rooftop PV will greatly affect the cost-effectiveness of a system. Numerous assumptions were applied to our study that may differ in an actual design, including roof size, roof pitch, orientation, shading, PV generation limits, and grid buy and sell rates. Our analysis provides a preliminary assessment for PV and solar hot water potential, but a project-specific assessment should be performed to better estimate the cost-effectiveness of on-site solar energy based on local factors. More information regarding solar potential simulation tools is available in Appendix C.2.

Figure 14. Rooftop solar energy systems can be especially beneficial to tribal lands, which have an outsized potential for renewable resources compared to the country as a whole (Doris 2013).
Photo from Ron Medvescek, Arizona Daily Star 2014

3.3 Building Energy Resilience Potential

The energy efficiency packages detailed in this report minimize total costs spread over the lifetime of buildings, leading to energy and utility costs savings. However, additional benefits of building energy resilience are also possible. Improving efficiency of the building envelope reduces strain and reliance on the HVAC system, which can ultimately help maintain safer indoor temperatures during periods of extreme weather or power outages. We consider two extreme scenarios to understand the potential benefits from our recommendations: (1) the June 2017 heat wave in Sells, Arizona, and (2) the January 2019 polar vortex in Bemidji, Minnesota, as detailed in Table 4. This study primarily focuses on the impacts to indoor temperature, as this is often correlated with risks to health and safety during extreme weather conditions. With results from this study, we can start to understand how possible EE packages can improve the energy resiliency of a home.

Table 4. Details of the two energy resilience analyses

Location	**Sells, AZ**	**Bemidji, MN**
Analysis dates	6/18/17 – 6/25/17	1/24/19 – 1/31/19
Simulated outages	None, 12-hour, 24-hour, and 5-day	None, 12-hour, 24-hour, and 5-day
Fuel type	Electric	Natural Gas
Description	Extreme heat exceeding 110°F for several days	Extreme cold ranging from -1°F to -38°F

We simulated the code minimum design and one energy-efficient package design for each of the two locations and heating fuel cases using actual meteorological year weather files. These designs were run for the analysis dates in Table 4 and simulated under normal utility operation as well as three different outage lengths, which helped demonstrate the resilience benefits of the upgrade package. Further details regarding the methodology of the resiliency study are available in Appendix B.3.

4 How to Use This Guide

This report is meant to guide building designers in selecting energy-efficient designs specific to their location. Section 5 presents five package recommendations for each location and fuel type case considered. Each set of tables and figures in that section is for a specific location and shows location-specific assumptions. Any of the five packages shown are commercially viable and should be chosen based on local availability and cost. The general steps to incorporating these recommendations are as follows:

1. Identify the appropriate **location** and **heating fuel** from Table 5
2. Confirm general geometry and high-level inputs align with Table 6
3. From the tables in Section 195, select the package best suited for the project-specific costs, materials, and labor to inform the building design.
   - **a.** With additional energy modeling: recommendations can be applied to refine and validate project-specific savings.
   - **b.** Without additional energy modeling: one can expect similar energy savings as listed, however, actual site energy savings cannot necessarily be demonstrated.

Step 3 relies on the EE recommendation tables in Section 5, a template of which is shown Figure 15 with explanations of the metrics. The color scale on the packages represents options that align with code minimum ranging to the most energy efficient, with that option being the darkest green. These tables demonstrate the various tradeoffs between options that still provide similar energy costs and savings. The *Site Energy Savings* and *Annualized Energy Cost Savings* metrics are calculated relative to the code minimum case, while the other two metrics are the absolute annualized cost and source energy use.

Category	Option	Code Minimum (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Envelope Options	Code minimum options selected					
Eqpt. & Lighting	Equipment & Lighting Options	Code minimum options selected					
Energy & Cost Metrics	Site Energy Savings (%)	% Energy savings compared to the IECC 2021 case					
	Annualized Energy Costs ($/yr)	Total cost of energy-related expenses during the lifetime of the home					
	Annualized Energy Costs Savings (%)	% Annualized energy costs savings compared to the IECC 2021 case					
	Source Energy Use (MMBtu/yr)	Primary energy required by a central power plant to produce fuel or electricity					

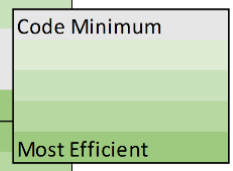


Figure 15. Format for the tables of recommended packages. Readers should consider each package individually based on the specific constraints of their project.

Packages represent different viable pathways to achieving similar levels of energy savings by introducing tradeoffs between option efficiencies; package numbers are not relevant.

Results from the preliminary analysis of rooftop PV and solar hot water potential are provided in the pages following the table of recommendations. The box in the upper left of these pages contains a number of output metrics which are described below:

Rooftop Solar

- Total PV generation (year 1):
  The total amount of electricity generated by the system in year 1
- Annual building electric load:
  Electricity usage per year (excludes other fuels)
- Total fraction of electric load met (year 1):
  Percent of load met in year 1
- Direct fraction of electric load met (year 1):
  Percent of load met directly at each hour, ignoring excess generation
- Electricity cost without PV (year 1):
  Cost of electric load without solar power
- Utility cost savings (w/ net metering) (year 1):
  Cost savings in year 1 when the excess power is sold back at the consumer electric rate
- Utility cost savings (w/o net metering) (year 1):
  Cost savings in year 1 when no excess power is sold
- System size:
  Size of the PV array (same for each case)

Solar Hot Water

- Estimated annual site energy savings:
  Reduction in site energy usage from the solar hot water system
- Utility cost savings:
  Reduction in site electricity costs from the solar hot water system
- Annualized cost savings:
  Difference in annualized cost when considering both the utility savings and initial investment with and without the SHW system

4.1 Input Reference

This section provides a quick reference of tables that are also provided elsewhere in the report to assist in the above steps to adopting recommendations.

Table 5. List of Locations, Heating Fuels, and Foundation Types Considered

IECC Climate Zone	City	IHS Area	Heating Fuel	Foundation Type
2B	Sells, AZ	Tucson	Electricity	Slab
2B	Sells, AZ	Tucson	Propane	Slab
2B	Parker, AZ	Phoenix	Electricity	Slab
2B	Parker, AZ	Phoenix	Propane	Slab
3A	Rock Hill, SC	Nashville	Electricity	Slab
3A	Rock Hill, SC	Nashville	Natural Gas	Slab
3B	Peach Springs, AZ	Phoenix	Electricity	Slab
3B	Peach Springs, AZ	Phoenix	Natural Gas	Slab
3C	Ukiah, CA	California	Natural Gas	Slab
3C	Ukiah, CA	California	Propane	Slab
4A	White Cloud, KS	Oklahoma	Natural Gas	Slab
4A	White Cloud, KS	Oklahoma	Propane	Slab
4B	San Fidel, NM	Albuquerque	Natural Gas	Slab
4B	San Fidel, NM	Albuquerque	Electricity	Slab
4C	Salem, OR	Portland	Electricity	Vented Crawlspace
4C	Salem, OR	Portland	Natural Gas	Vented Crawlspace
5A	Rosebud, SD	Great Plains	Electricity	Slab
5A	Rosebud, SD	Great Plains	Propane	Slab
5B	Dulce, NM	Albuquerque	Natural Gas	Slab
5B	Dulce, NM	Albuquerque	Electricity	Slab
5B	Warm Springs, OR	Portland	Electricity	Slab
5B	Warm Springs, OR	Portland	Natural Gas	Slab
5B	Window Rock, AZ	Navajo	Electricity	Slab
5B	Window Rock, AZ	Navajo	Propane	Slab
6A	Eagle Butte, SD	Great Plains	Electricity	Heated Basement
6A	Eagle Butte, SD	Great Plains	Propane	Heated Basement
6B	Crow Agency, MT	Billings	Natural Gas	Heated Basement
6B	Crow Agency, MT	Billings	Propane	Heated Basement
6B	Ft Washakie, WY	Billings	Natural Gas	Heated Basement
6B	Ft Washakie, WY	Billings	Propane	Heated Basement
7A	Bemidji, MN	Bemidji	Natural Gas	Heated Basement
7A	Bemidji, MN	Bemidji	Electricity	Heated Basement
7A	Belcourt, ND	Great Plains	Electricity	Heated Basement
7A	Belcourt, ND	Great Plains	Fuel Oil	Heated Basement

IECC Climate Zone	City	IHS Area	Heating Fuel	Foundation Type
7	Anchorage, AK	Alaska	Natural Gas	Slab
7	Anchorage, AK	Alaska	Electricity	Slab
8	Utqiagvik, AK	Alaska	Natural Gas	Raised Foundation
8	Utqiagvik, AK	Alaska	Fuel Oil	Raised Foundation

Table 6. High-Level Baseline Inputs

Input	Value
Above-Grade Square Footage	1,400 ft^2/unit
Units	2
Above-Grade Stories[a]	1
Bedrooms	2/unit
Bathrooms	1/unit
Garage	1-car/unit
Wall Type	Wood frame[b]
Attic Type	Vented attic[c]
Foundation Type	Specified in Table A-1
Window To Wall Ratios	9% at each facade
Building Orientation	North
HVAC	Heating and cooling present[d]
Analysis Lifetime	40 years
Inflation Rate	2.4%

[a] Some locations include below-grade finished basements, which match footprint of above-grade space (Table A-1).
[b] Utqiagvik, AK cases have structural insulated panels (SIP).
[c] Utqiagvik, AK cases have finished roofs.
[d] Cooling is not present in Utqiagvik, AK

5 Energy Efficiency Packages and Solar Energy Recommendations

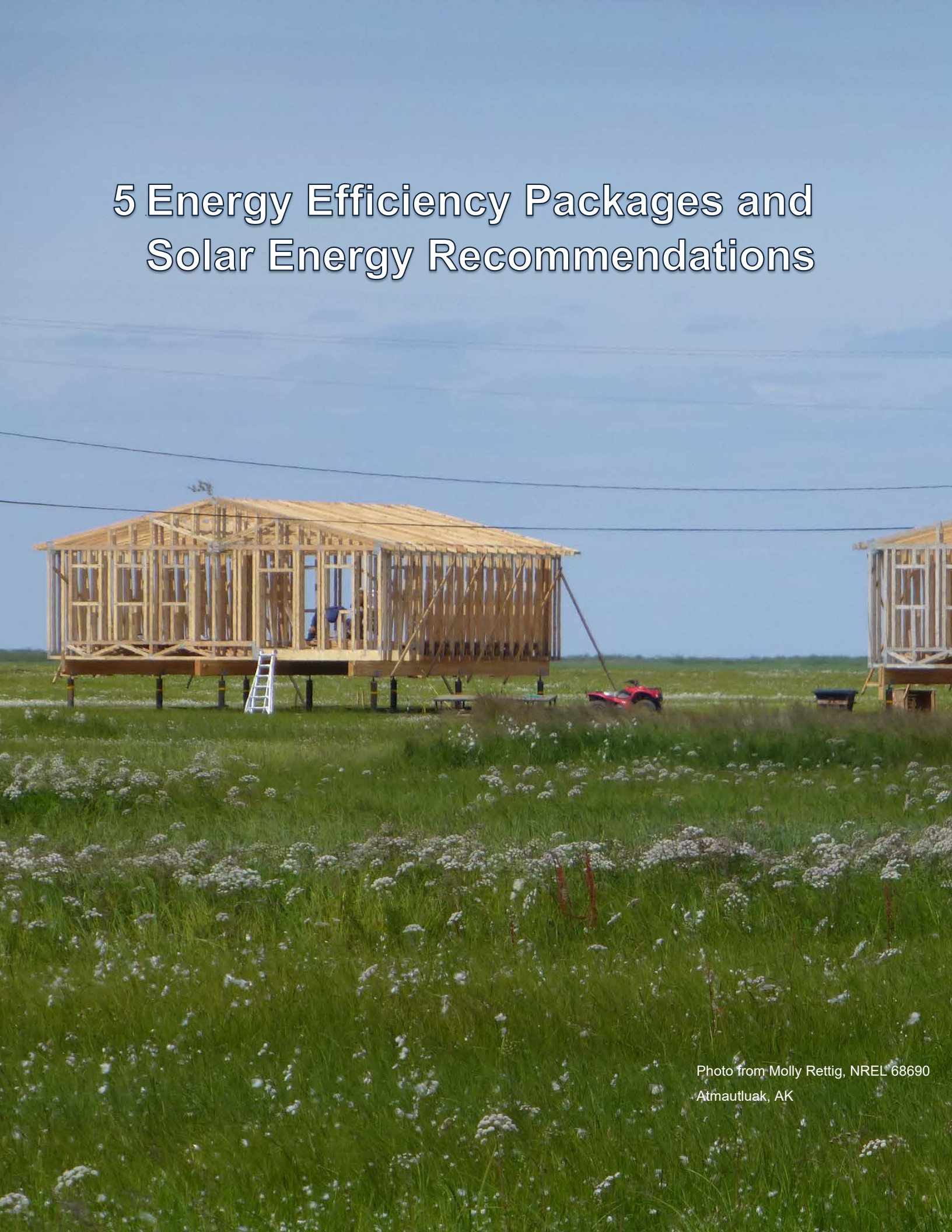


Photo from Molly Rettig, NREL 68690
Atmautluak, AK

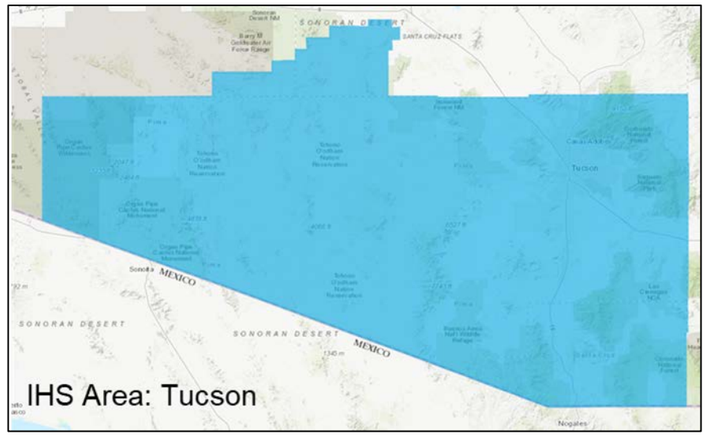
5.1 Climate Zone 2B – Sells, AZ (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Representative City: Sells, AZ
Heating Setpoint: 72°F
Cooling Setpoint: 75°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–50	$ 0.235
51–200	$ 0.145
201+	$ 0.1085



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-13 Fiberglass, 2x4, 16"
	Wall Sheathing	None	None	R-5 XPS	R-5 XPS	None	None
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass
	Radiant Barrier	None	None	None	Double-Sided, Foil	None	None
	Slab	Uninsulated	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R5 Exterior XPS	Uninsulated
	Windows	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25
	Air Leakage	5 ACH50	3 ACH50	2 ACH50	2 ACH50	4 ACH50	5 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 16, 8.6 HSPF	SEER 16, 8.6 HSPF	SEER 16, 8.6 HSPF	SEER 18, 9.3 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	19.4%	20.5%	20.5%	19.4%	20.5%
	Ann. Energy Costs ($/yr)	2,488	2,149	2,167	2,175	2,176	2,223
	Ann. Energy Costs Savings (%)	0.0%	13.6%	12.9%	12.6%	12.5%	10.6%
	Source Energy Use (MMBtu/yr)	180.3	143.8	141.7	141.6	143.8	141.6

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Potential

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

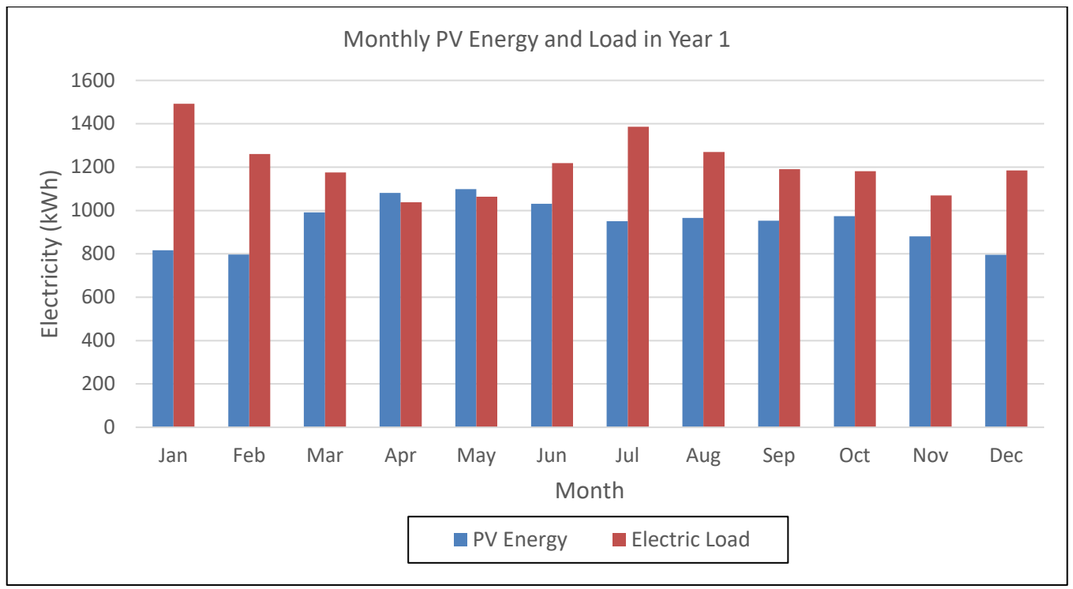
Rooftop Solar

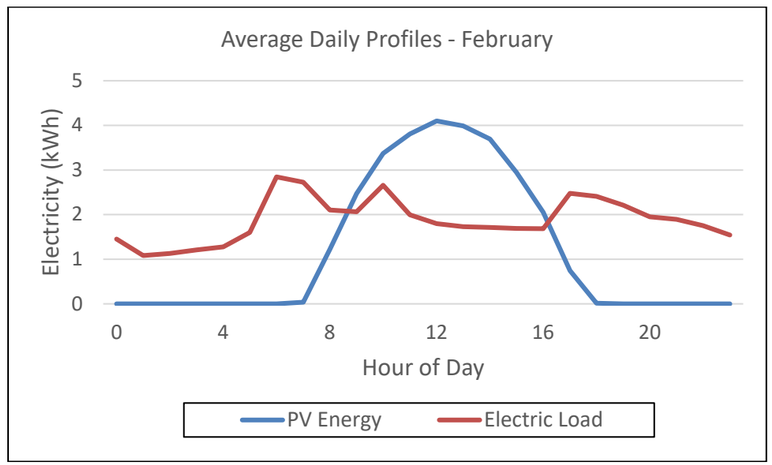
- Total PV generation (year 1): **11,336 kWh (1,744 kWh/kWdc)**
- Annual building electric load: **14,528 kWh**
- Total fraction of electric load met (year 1): **78.0%**
- Direct fraction of electric load met (year1): **41.0%**
- Electricity cost without PV (year 1): **$1,718**
- Utility cost savings (w/ net metering) (year 1): **$1,373**
- Utility cost savings (w/o net metering) (year 1): **$646**
- System size: **6.5 kWdc**

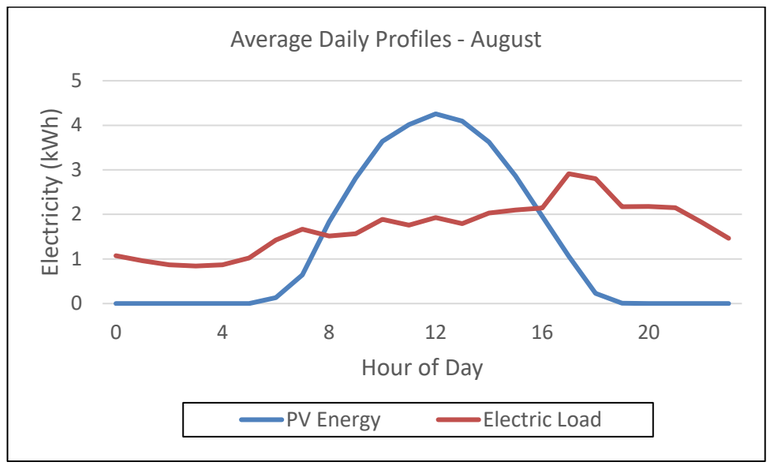
Annualized cost savings (w/ net metering): **$606**
Annualized cost savings (w/o net metering): **-$121**

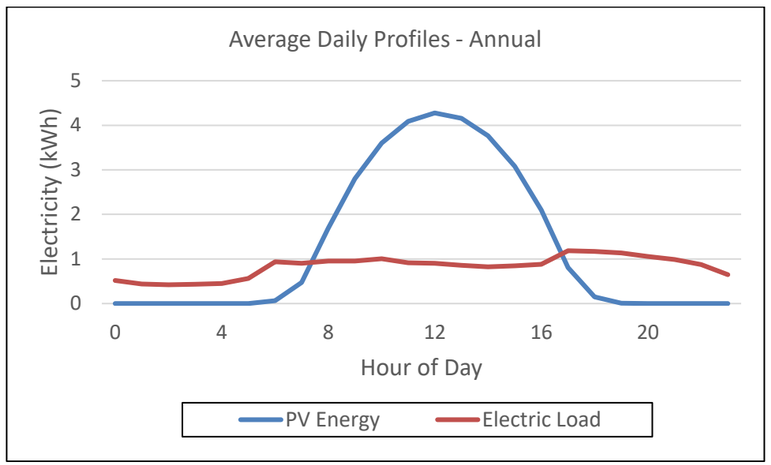
Solar Hot Water

- Estimated annual site energy savings: **18.6%**
- Utility cost savings: **$323/yr**
- Annualized cost savings: **-$260/yr**









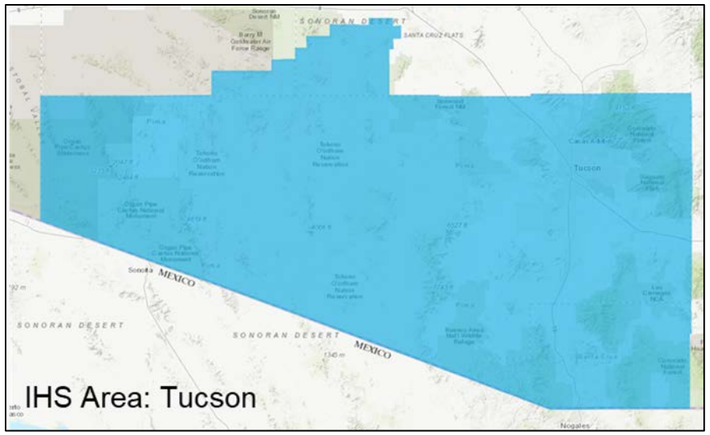
5.2 Climate Zone 2B – Sells, AZ (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Representative City: Sells, AZ
Heating Setpoint: 72°F
Cooling Setpoint: 75°F
Foundation Type: Slab
Propane Rate: $3.00/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–50	$ 0.235
51–200	$ 0.145
201+	$ 0.1085



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	None	R-10 XPS	R-15 XPS	R-5 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	Uninsulated	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS
	Windows	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.19, SHGC = 0.25
	Air Leakage	5 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	HRV, 70% SRE	ASHRAE 62.2 Standard
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 18	SEER 21	SEER 16	SEER 14
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	21.8%	23.4%	22.6%	24.3%	21.3%
	Ann. Energy Costs ($/yr)	2,892	2,437	2,456	2,482	2,506	2,509
	Ann. Energy Costs Savings (%)	0.0%	15.7%	15.1%	14.2%	13.3%	13.3%
	Source Energy Use (MMBtu/yr)	149.1	123.3	120.5	120.2	123.7	126.5

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

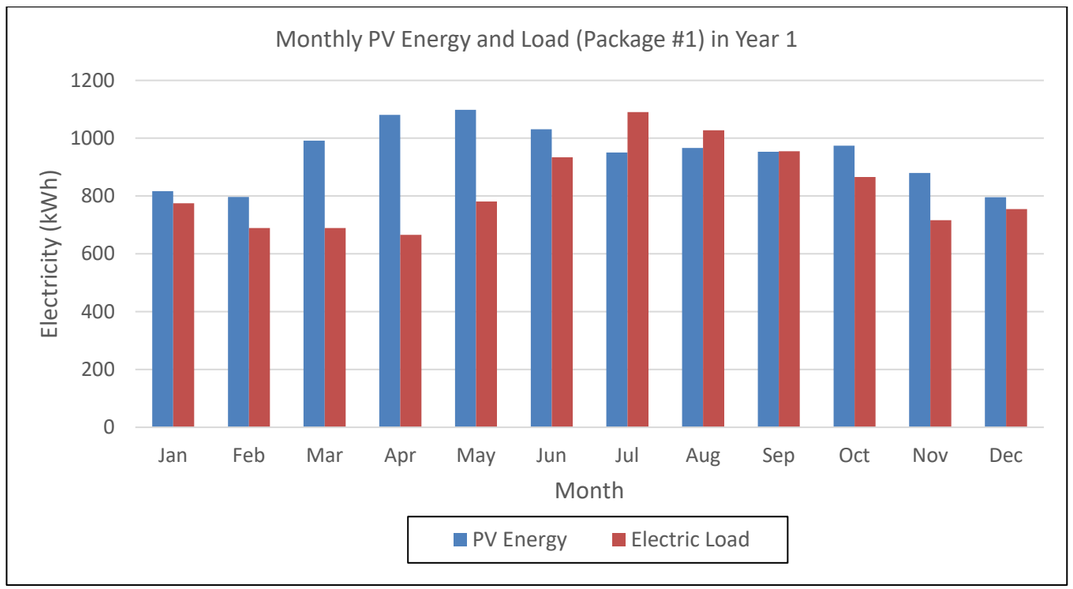
Rooftop Solar

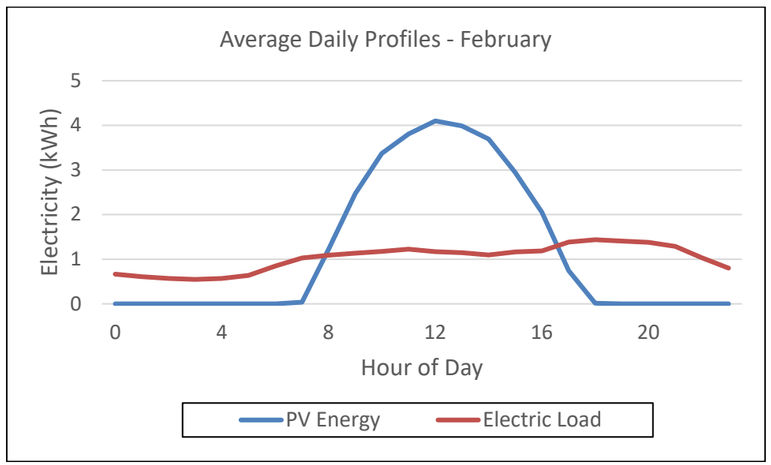
- Total PV generation (year 1): **11,336 kWh (1,744 kWh/kWdc)**
- Annual building electric load: **9,944 kWh**
- Total fraction of electric load met (year 1): **114.0%**
- Direct fraction of electric load met (year 1): **45.8%**
- Electricity cost without PV (year 1): **$1,221**
- Utility cost savings (w/ net metering) (year 1): **$1,374**
- Utility cost savings (w/o net metering) (year 1): **$726**
- System size: **6.5 kWdc**

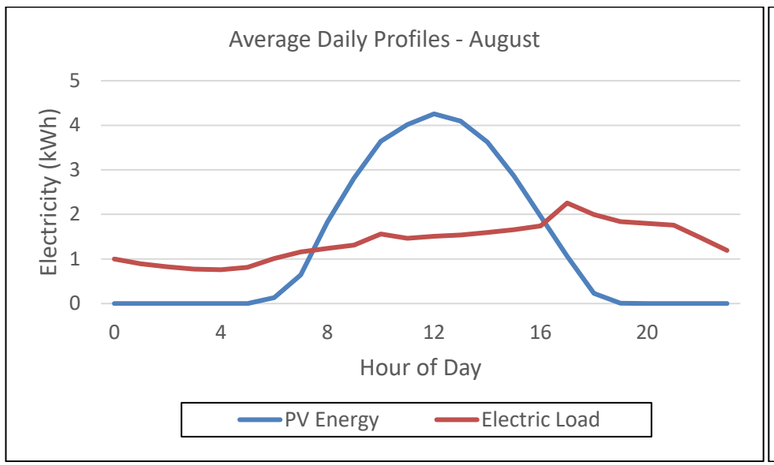
Annualized cost savings (w/ net metering): **$607**
Annualized cost savings (w/o net metering): **-$41**

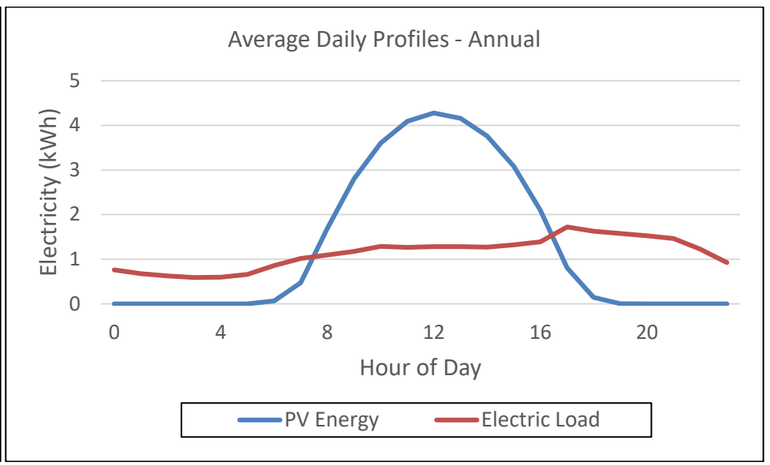
Solar Hot Water

- Estimated annual site energy savings: **20.5%**
- Utility cost savings: **$415/yr**
- Annualized cost savings: **-$166/yr**









5.3 Climate Zone 2B – Parker, AZ (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Representative City: Parker, AZ
Heating Setpoint: 72°F
Cooling Setpoint: 75°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–499	$ 0.172
500–999	$ 0.173
1000–1499	$ 0.174
1500+	$ 0.175

Category	Option	Code Minimum (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	None	R-5 XPS	R-5 XPS	R-15 XPS	None	R-15 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	Double-Sided, Foil
	Slab	Uninsulated	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS
	Windows	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.37, SHGC = 0.25
	Air Leakage	5 ACH50	2 ACH50	2 ACH50	1 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	21.2%	21.1%	22.0%	20.8%	22.4%
	Annualized Energy Costs ($/yr)	3,183	2,691	2,693	2,717	2,734	2,736
	Annualized Energy Costs Savings (%)	0.0%	15.5%	15.4%	14.7%	14.1%	14.1%
	Source Energy Use (MMBtu/yr)	176.5	139.1	139.3	137.6	139.7	136.9

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

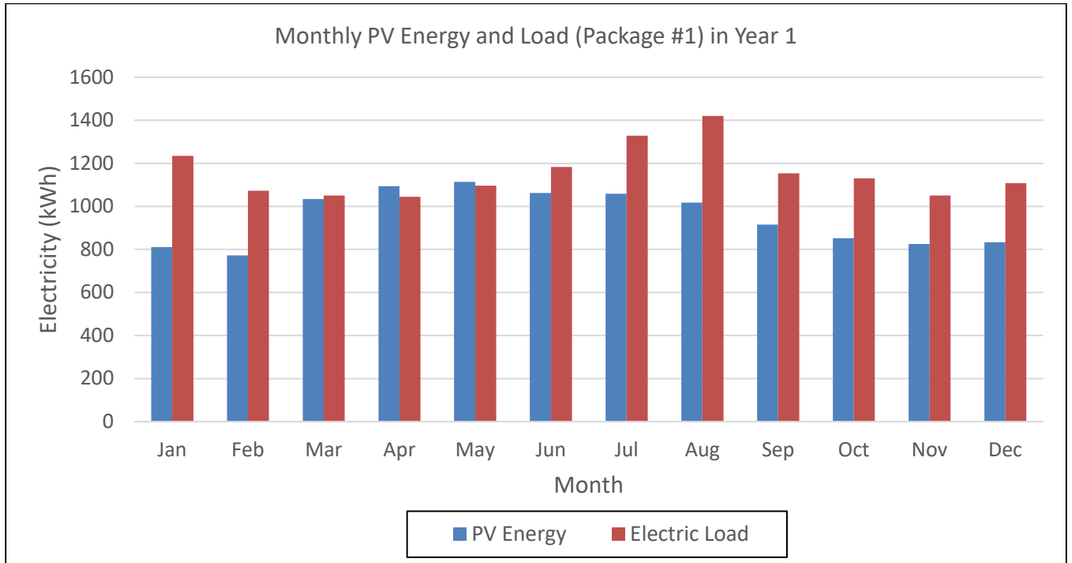
Rooftop Solar

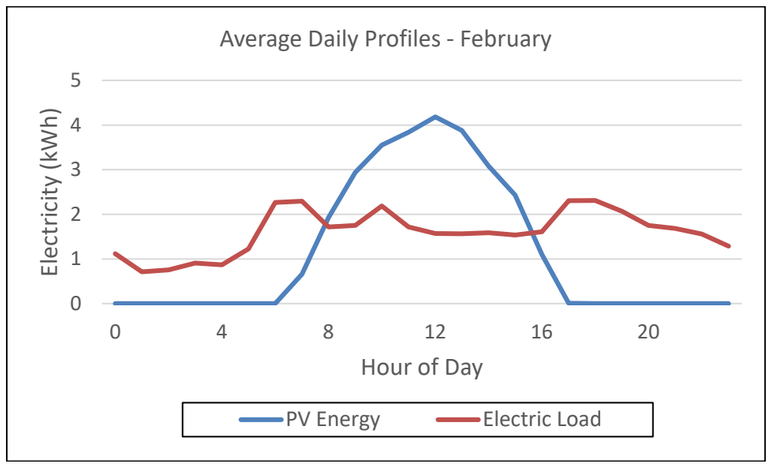
- Total PV generation (year 1): **11,391 kWh (1,752 kWh/kWdc)**
- Annual building electric load: **13,876 kWh**
- Total fraction of electric load met (year 1): **82.1%**
- Direct fraction of electric load met (year1): **44.9%**
- Electricity cost without PV (year 1): $**2,396**
- Utility cost savings (w/ net metering) (year 1): **$1,969**
- Utility cost savings (w/o net metering) (year 1): **$1,025**
- System size: **6.5 kWdc**

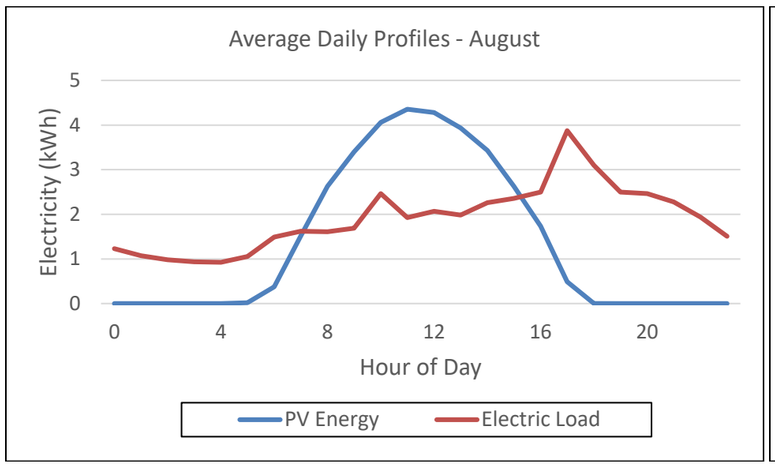
Annualized cost savings (w/ net metering): **$1,202**
Annualized cost savings (w/o net metering): **$258**

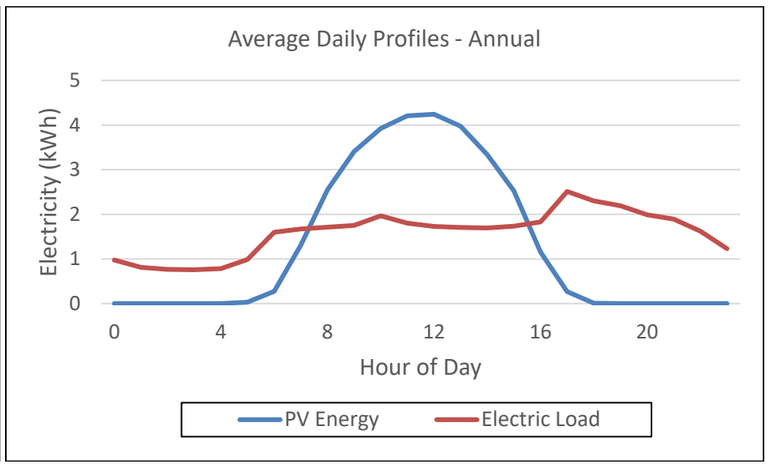
Solar Hot Water

- Estimated annual site energy savings: **16.8%**
- Utility cost savings: **$424/yr**
- Annualized cost savings: **-$158/yr**









5.4 Climate Zone 2B – Parker, AZ (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Representative City: Parker, AZ
Heating Setpoint: 72°F
Cooling Setpoint: 75°F
Foundation Type: Slab
Propane Rate: $3.67/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–499	$ 0.172
500–999	$ 0.173
1000–1499	$ 0.174
1500+	$ 0.175

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	None	R-5 XPS	R-10 XPS	R-15 XPS	R-5 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	Double-Sided, Foil	None	Double-Sided, Foil
	Slab	Uninsulated	2ft R10 Exterior XPS	2ft R5 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS	2ft R10 Exterior XPS
	Windows	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.37, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.37, SHGC = 0.25
	Air Leakage	5 ACH50	2 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 24.5	SEER 24.5	SEER 24.5	SEER 24.5	SEER 21
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	27.2%	27.2%	28.5%	27.4%	26.5%
	Ann. Energy Costs ($/yr)	3,363	2,655	2,671	2,686	2,693	2,708
	Ann. Energy Costs Savings (%)	0.0%	21.0%	20.6%	20.1%	19.9%	19.5%
	Source Energy Use (MMBtu/yr)	160.2	120.	120.2	118.	119.7	122.1

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

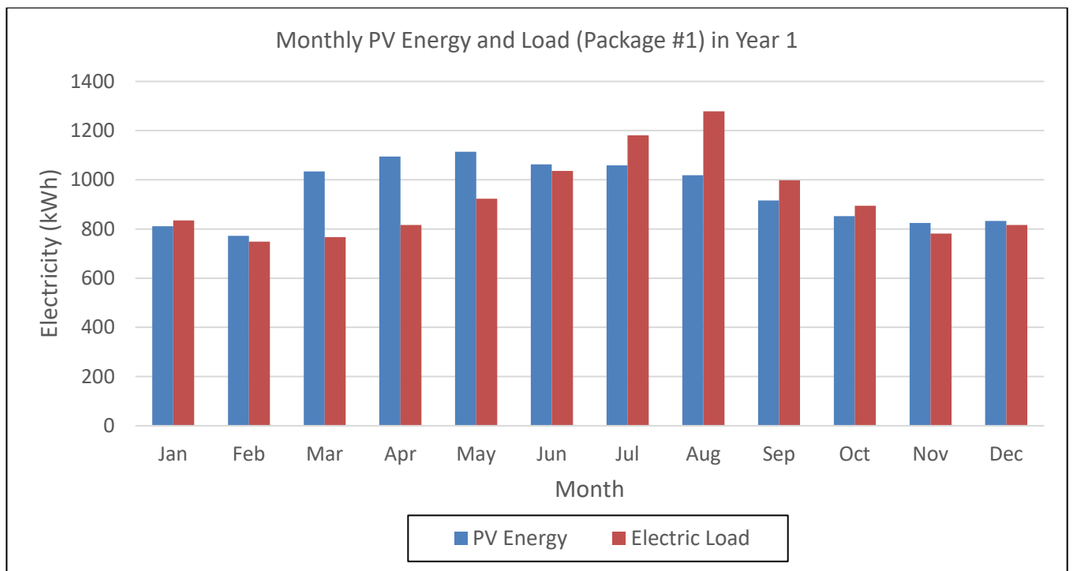
Rooftop Solar

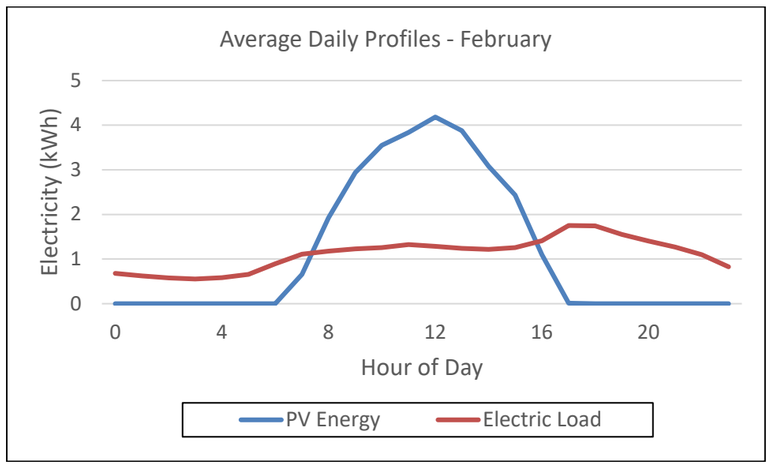
- Total PV generation (year 1): **11,391 kWh (1,752 kWh/kWdc)**
- Annual building electric load: **11,075 kWh**
- Total fraction of electric load met (year 1): **102.9%**
- Direct fraction of electric load met (year 1): **44.9%**
- Electricity cost without PV (year 1): $**2,030**
- Utility cost savings (w/ net metering) (year 1): **$1,906**
- Utility cost savings (w/o net metering) (year 1): **$861**
- System size: **6.5 kWdc**

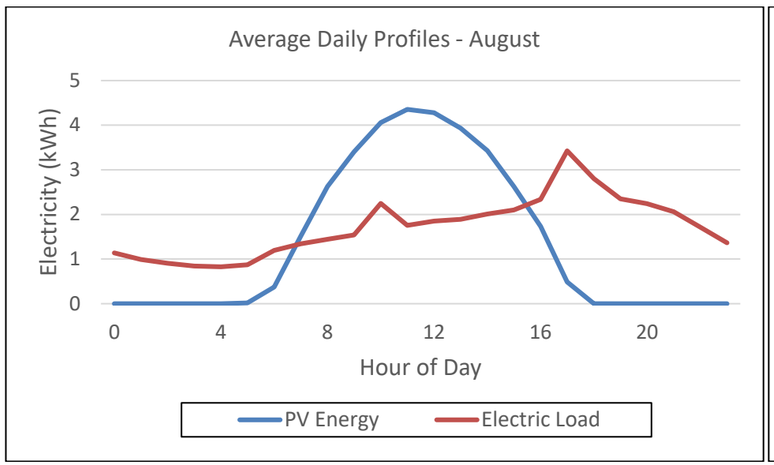
Annualized cost savings (w/ net metering): **$1,139**
Annualized cost savings (w/o net metering): **$94**

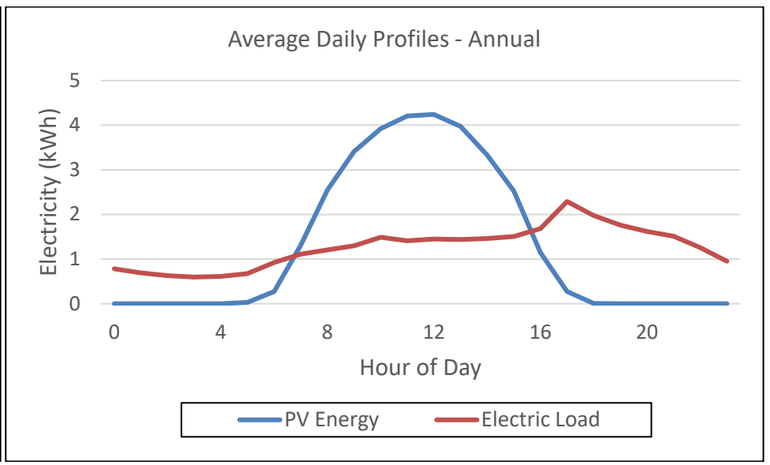
Solar Hot Water

- Estimated annual site energy savings: **19.8%**
- Utility cost savings: **$405/yr**
- Annualized cost savings: **-$177/yr**









5.5 Climate Zone 3A – Rock Hill, SC (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.145
500–1000	$ 0.13
1000–1500	$ 0.126
1500+	$ 0.123

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-5 XPS	R-5 XPS	R-5 XPS	R-5 XPS	None
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	2ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R10 Exterior XPS	2ft R10 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	3 ACH50	3 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 16, 8.6 HSPF	SEER 16, 8.6 HSPF	SEER 18, 9.3 HSPF	SEER 19, 9.5 HSPF	SEER 19, 9.5 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	20.3%	20.7%	20.5%	21.1%	20.3%
	Ann. Energy Costs ($/yr)	2,799	2,335	2,345	2,350	2,354	2,364
	Ann. Energy Costs Savings (%)	0.0%	16.6%	16.2%	16.0%	15.9%	15.5%
	Source Energy Use (MMBtu/yr)	192.	151.4	150.5	150.9	149.7	151.4

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

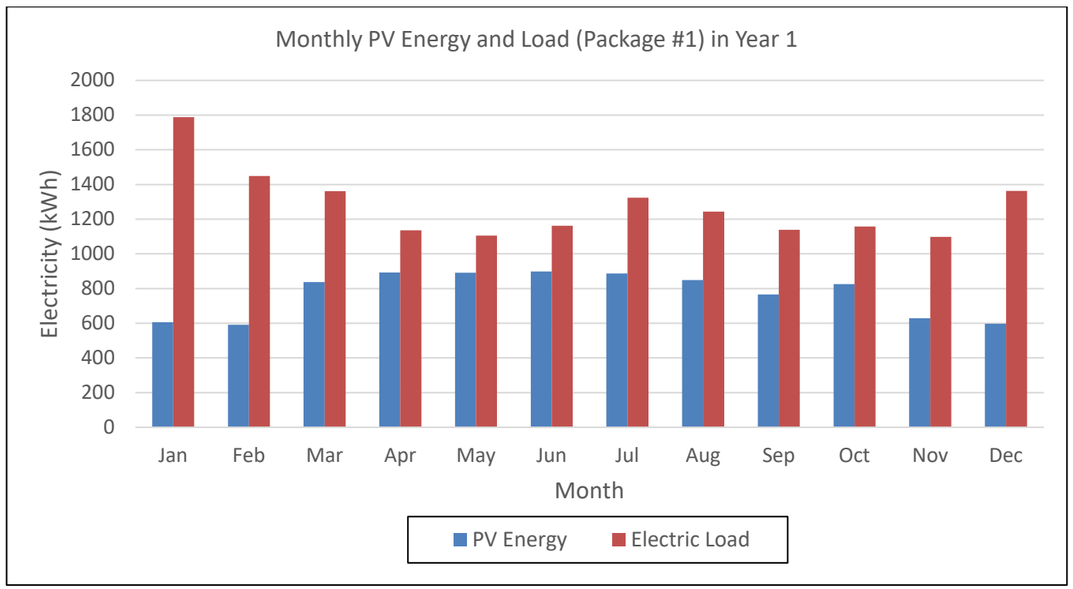
Rooftop Solar

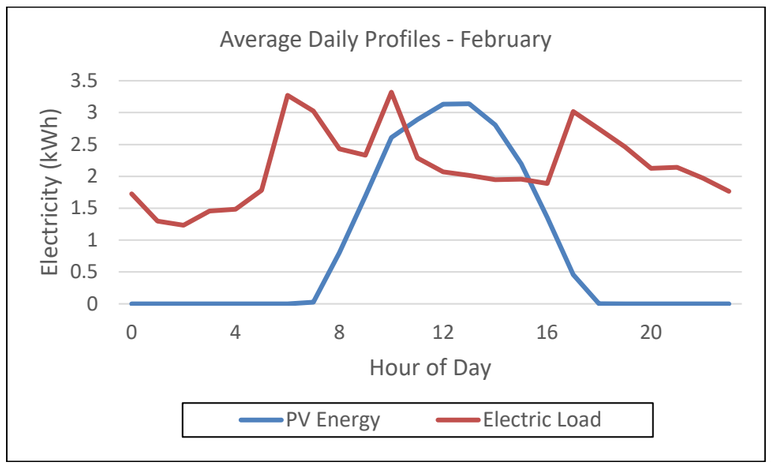
- Total PV generation (year 1): **9,273 kWh (1,427 kWh/kWdc)**
- Annual building electric load: **15,326 kWh**
- Total fraction of electric load met (year 1): **60.5%**
- Direct fraction of electric load met (year 1): **36.1%**
- Electricity cost without PV (year 1): $**2,068**
- Utility cost savings (w/ net metering) (year 1): **$1,249**
- Utility cost savings (w/o net metering) (year 1): **$706**
- System size: **6.5 kWdc**

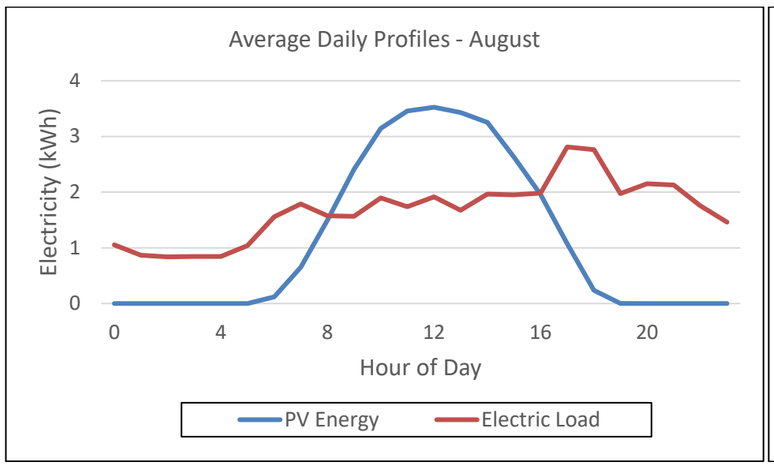
Annualized cost savings (w/ net metering): **$482**
Annualized cost savings (w/o net metering): **-$61**

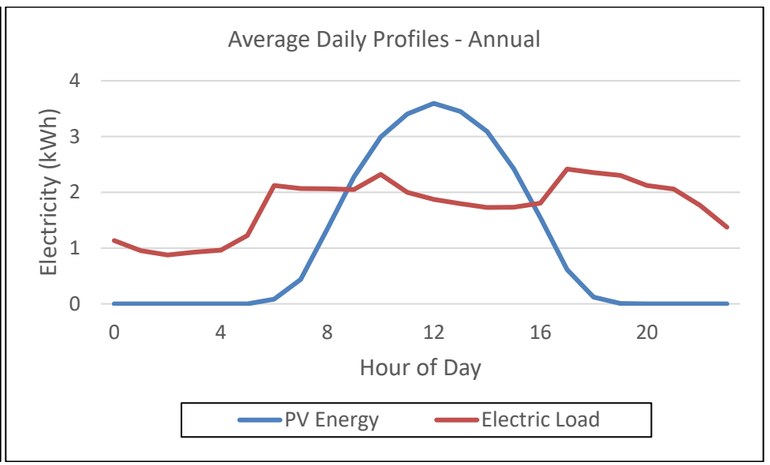
Solar Hot Water

- Estimated annual site energy savings: **15.9%**
- Utility cost savings: **$355/yr**
- Annualized cost savings: **-$226/yr**









5.6 Climate Zone 3A – Rock Hill, SC (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Natural Gas Rate: $1.31/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.145
500–1000	$ 0.13
1000–1500	$ 0.126
1500+	$ 0.123

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-10 XPS	R-5 XPS	R-10 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	2ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	1 ACH50	1 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 18	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 80% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	16.9%	16.6%	20.2%	20.5%	16.8%
	Ann. Energy Costs ($/yr)	2,135	1,911	1,923	1,929	1,940	1,980
	Ann. Energy Costs Savings (%)	0.0%	10.5%	9.9%	9.7%	9.1%	7.3%
	Source Energy Use (MMBtu/yr)	150.5	130.3	129.7	127.3	126.7	130.6

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

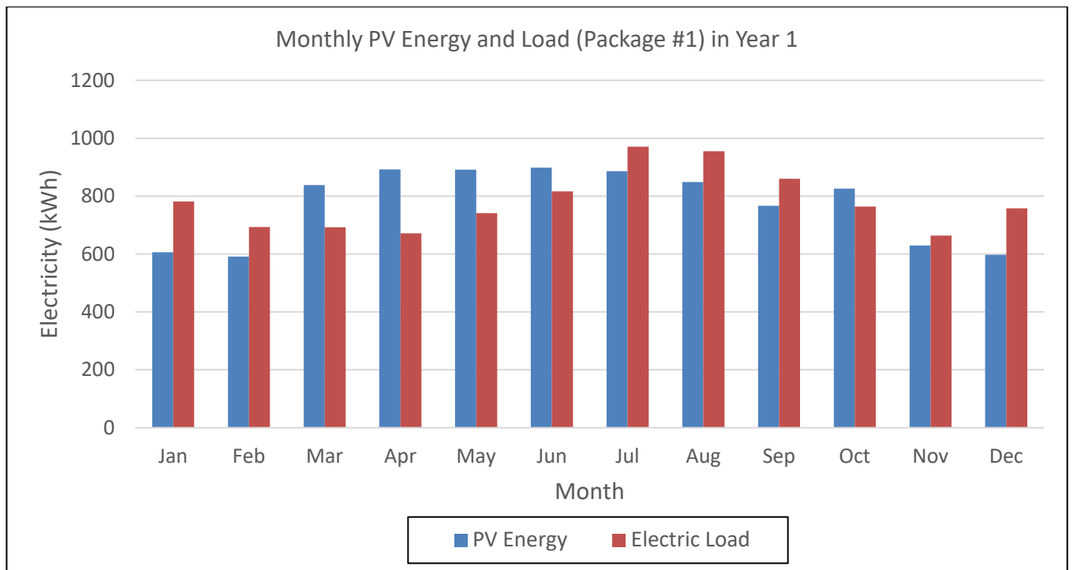
Rooftop Solar

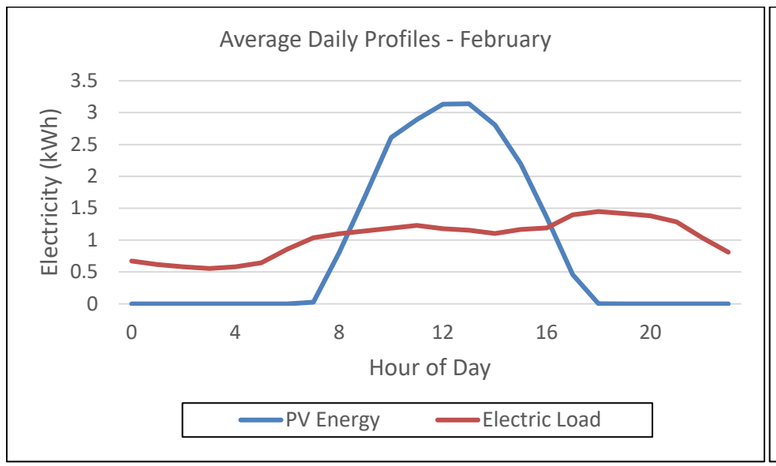
- Total PV generation (year 1): **9,273 kWh (1,427 kWh/kWdc)**
- Annual building electric load: **11,075 kWh**
- Total fraction of electric load met (year 1): **99.0%**
- Direct fraction of electric load met (year 1): **43.9%**
- Electricity cost without PV (year 1): $**1,308**
- Utility cost savings (w/ net metering) (year 1): **$1,293**
- Utility cost savings (w/o net metering) (year 1): **$546**
- System size: **6.5 kWdc**

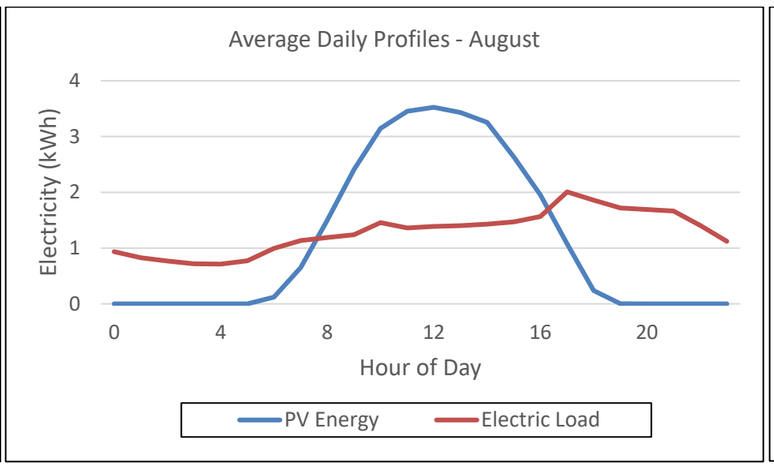
Annualized cost savings (w/ net metering): **$526**
Annualized cost savings (w/o net metering): **-$221**

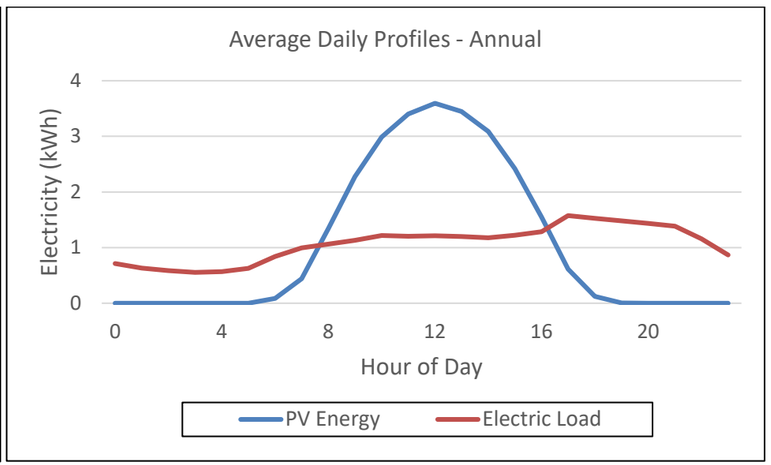
Solar Hot Water

- Estimated annual site energy savings: **18.5%**
- Utility cost savings: **$132/yr**
- Annualized cost savings: **-$450/yr**









5.7 Climate Zone 3B – Peach Springs, AZ (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.173
1000–1500	$ 0.174
1500+	$ 0.175

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-10 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	Double-Sided, Foil	None	None
	Slab	2ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.19, SHGC = 0.25	U = 0.29, SHGC = 0.25
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	2 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	HRV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	27.5%	27.5%	27.3%	27.2%	27.5%
	Ann. Energy Costs ($/yr)	3,548	2,747	2,748	2,794	2,804	2,847
	Ann. Energy Costs Savings (%)	0.0%	22.6%	22.6%	21.3%	21.0%	19.8%
	Source Energy Use (MMBtu/yr)	197.1	140.5	140.6	141.1	141.3	140.6

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

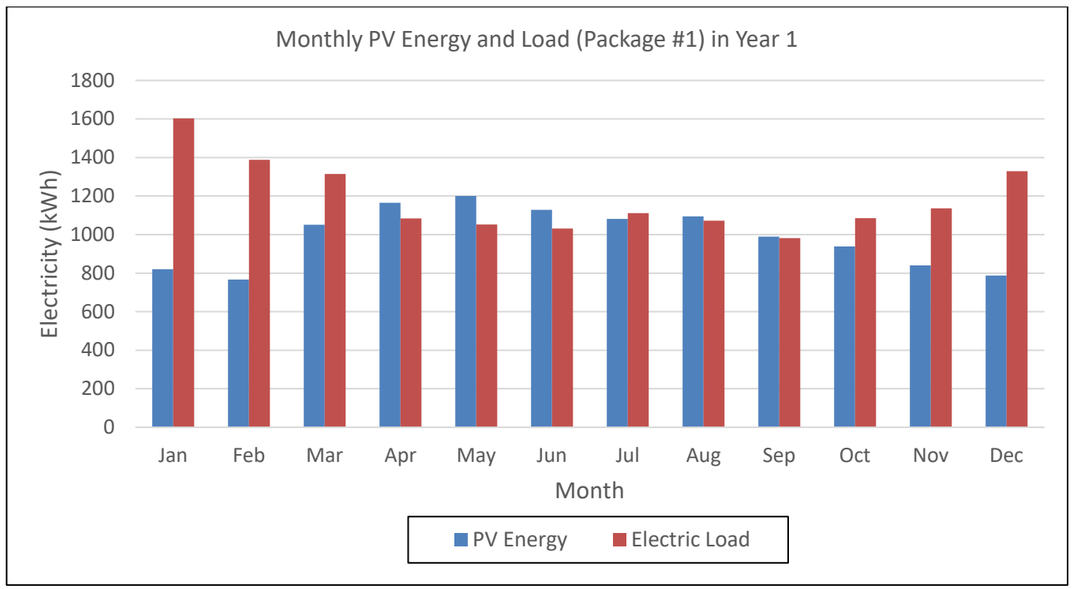
Rooftop Solar

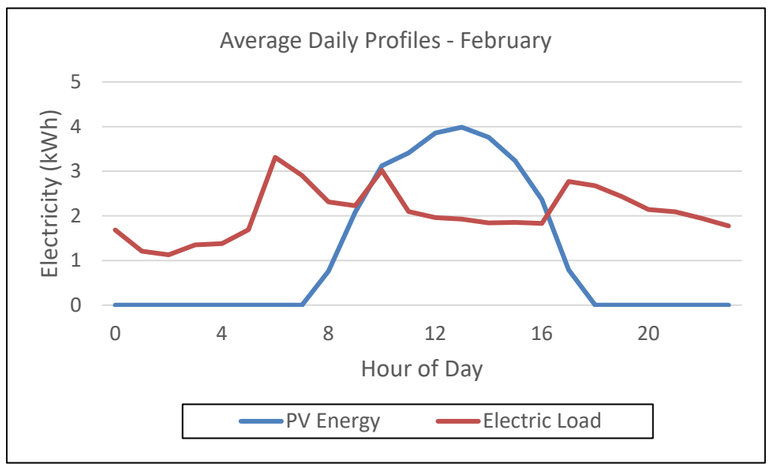
- Total PV generation (year 1): **11,863 kWh (1,825 kWh/kWdc)**
- Annual building electric load: **14,187 kWh**
- Total fraction of electric load met (year 1): **83.6%**
- Direct fraction of electric load met (year 1): **40.7%**
- Electricity cost without PV (year 1): **$2,451**
- Utility cost savings (w/ net metering) (year 1): **$2,049**
- Utility cost savings (w/o net metering) (year 1): **$1,000**
- System size: **6.5 kWdc**

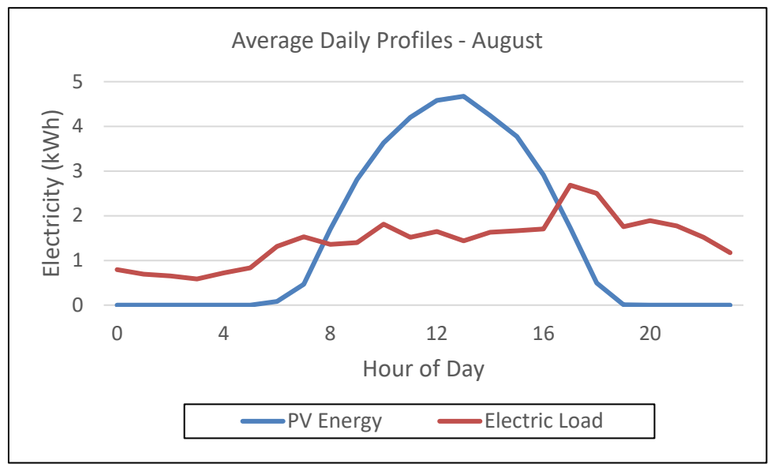
Annualized cost savings (w/ net metering): **$1,282**
Annualized cost savings (w/o net metering): **$233**

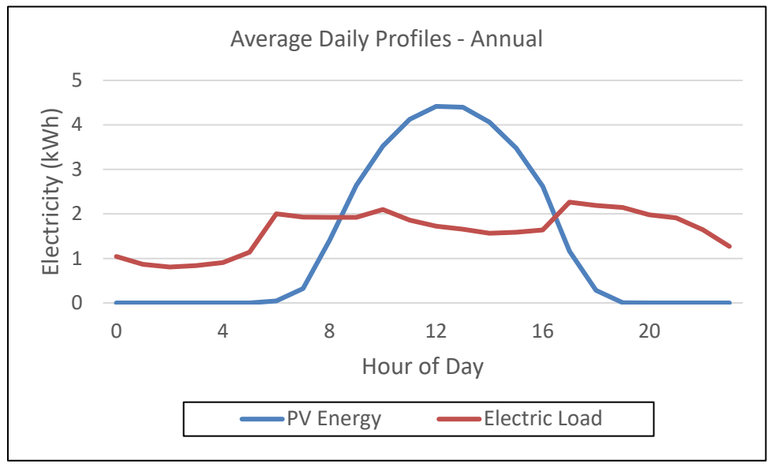
Solar Hot Water

- Estimated annual site energy savings: **20.1%**
- Utility cost savings: **$542/yr**
- Annualized cost savings: **-$40/yr**









5.8 Climate Zone 3B – Peach Springs, AZ (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Natural Gas Rate: $1.51/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.173
1000–1500	$ 0.174
1500+	$ 0.175

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	Double-Sided, Foil	None	Double-Sided, Foil	None
	Slab	2ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.19, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.17, SHGC = 0.25
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 21	SEER 18
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	21.2%	23.3%	20.7%	20.8%	26.4%
	Ann. Energy Costs ($/yr)	2,561	2,204	2,235	2,244	2,261	2,262
	Ann. Energy Costs Savings (%)	0.0%	13.9%	12.7%	12.4%	11.7%	11.7%
	Source Energy Use (MMBtu/yr)	153.5	127.9	125.9	128.2	126.6	122.1

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

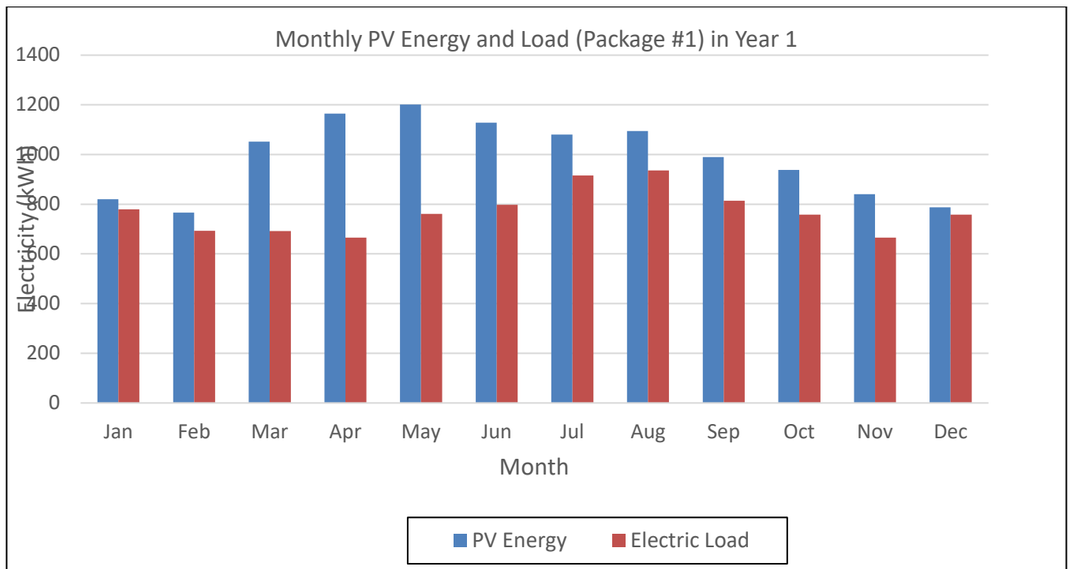
Rooftop Solar

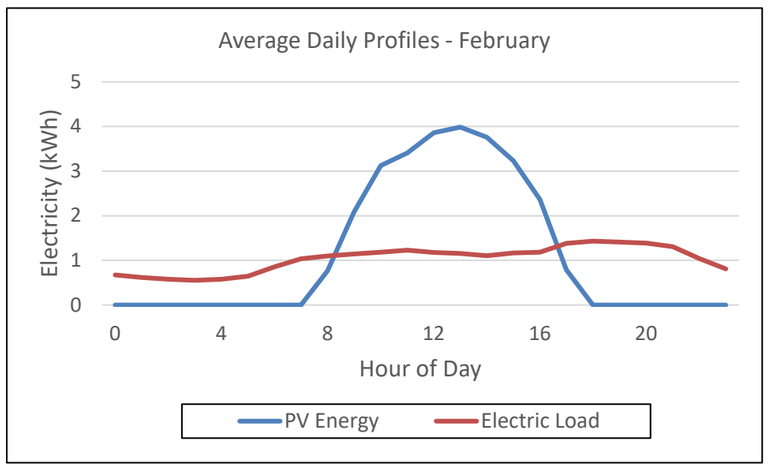
- Total PV generation (year 1): **11,863 kWh (1,825 kWh/kWdc)**
- Annual building electric load: **9,237 kWh**
- Total fraction of electric load met (year 1): **128.4%**
- Direct fraction of electric load met (year 1): **46.9%**
- Electricity cost without PV (year 1): **$1,592**
- Utility cost savings (w/ net metering) (year 1): **$2,045**
- Utility cost savings (w/o net metering) (year 1): **$748**
- System size: **6.5 kWdc**

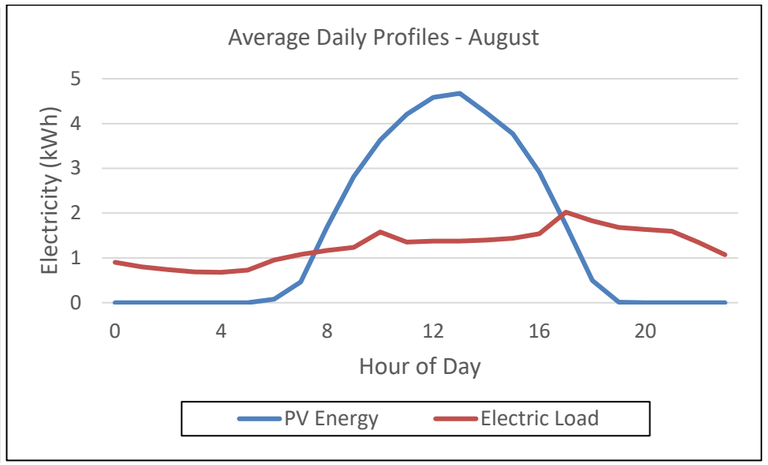
Annualized cost savings (w/ net metering): **$1,278**
Annualized cost savings (w/o net metering): **-$19**

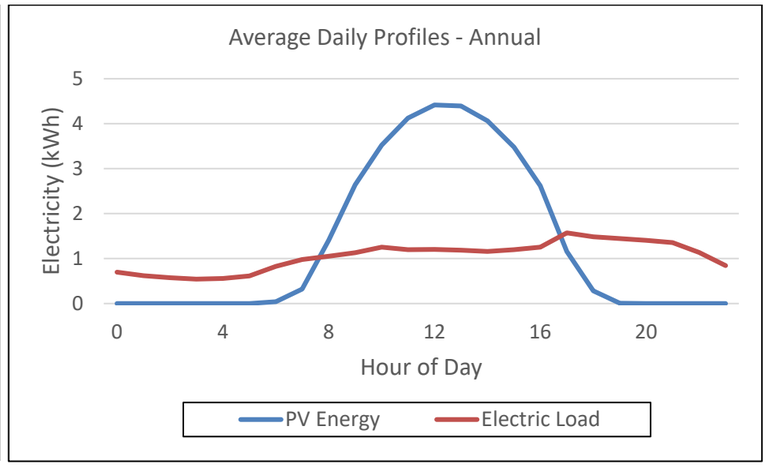
Solar Hot Water

- Estimated annual site energy savings: **19.8%**
- Utility cost savings: **$184/yr**
- Annualized cost savings: **-$398/yr**









5.9 Climate Zone 3C – Ukiah, CA (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 68F
Cooling Setpoint: 72°F
Foundation Type: Slab
Natural Gas Rate: $1.83/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.276
500–1000	$ 0.312
1000–1500	$ 0.327
1500+	$ 0.339

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-10 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-49 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	2ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.17, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	1 ACH50	1 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	HRV, 70% SRE	ERV, 70% SRE
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 14	SEER 14	SEER 16 (2 Stage)
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	16.9%	16.6%	20.0%	20.8%	16.9%
	Ann. Energy Costs ($/yr)	3,436	3,129	3,132	3,159	3,199	3,250
	Ann. Energy Costs Savings (%)	0.0%	8.9%	8.8%	8.1%	6.9%	5.4%
	Source Energy Use (MMBtu/yr)	143.1	124.4	124.7	122.3	123.6	126.8

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

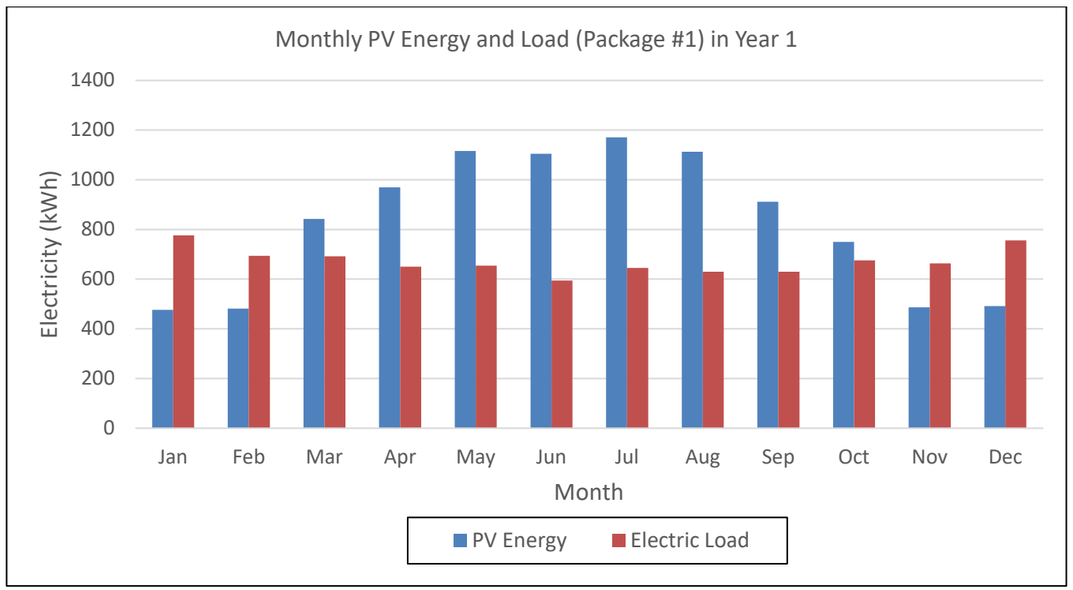
Rooftop Solar

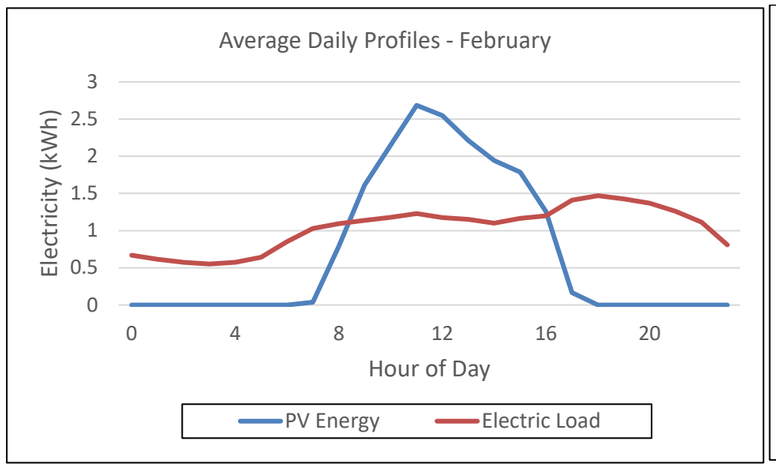
- Total PV generation (year 1): **9,915 kWh (1,525 kWh/kWdc)**
- Annual building electric load: **8,063 kWh**
- Total fraction of electric load met (year 1): **123.0%**
- Direct fraction of electric load met (year 1): **43.7%**
- Electricity cost without PV (year 1): $**2,300**
- Utility cost savings (w/ net metering) (year 1): **$2,858**
- Utility cost savings (w/o net metering) (year 1): **$1,045**
- System size: **6.5 kWdc**

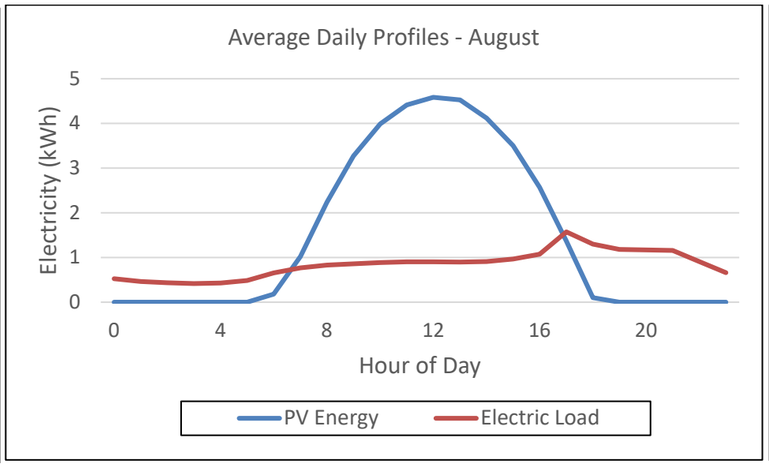
Annualized cost savings (w/ net metering): **$2,091**
Annualized cost savings (w/o net metering): **$278**

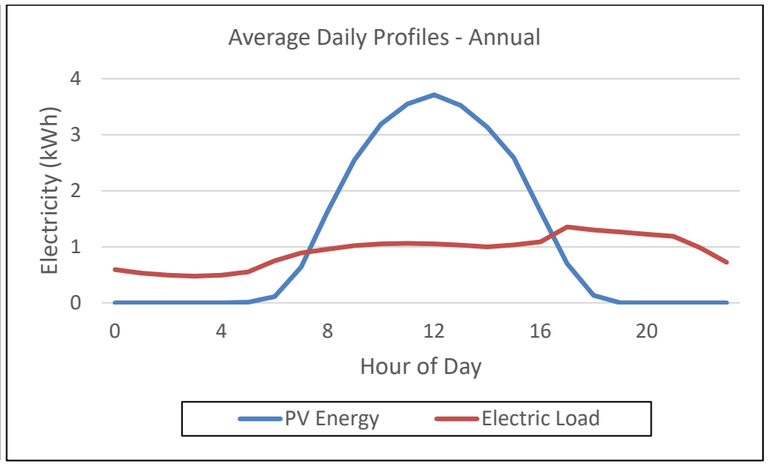
Solar Hot Water

- Estimated annual site energy savings: **18.3%**
- Utility cost savings: **$179/yr**
- Annualized cost savings: **-$402/yr**









5.10 Climate Zone 3C – Ukiah, CA (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 68F
Cooling Setpoint: 72°F
Foundation Type: Slab
Propane Rate: $3.43/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.276
500–1000	$ 0.312
1000–1500	$ 0.327
1500+	$ 0.339

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-49 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	2ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.29, SHGC = 0.25	U = 0.17, SHGC = 0.25	U = 0.17, SHGC = 0.25	U = 0.26, SHGC = 0.25
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	HRV, 70% SRE	HRV, 70% SRE	ERV, 70% SRE	HRV, 70% SRE	HRV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 14	SEER 14	SEER 14	SEER 14	SEER 16 (2 Stage)
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 94% AFUE	Propane, 96% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	18.1%	17.6%	21.9%	22.2%	22.2%
	Ann. Energy Costs ($/yr)	4,451	3,996	4,006	4,072	4,125	4,146
	Ann. Energy Costs Savings (%)	0.0%	10.2%	10.0%	8.5%	7.3%	6.9%
	Source Energy Use (MMBtu/yr)	148.5	129.9	130.5	126.	125.8	124.9

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

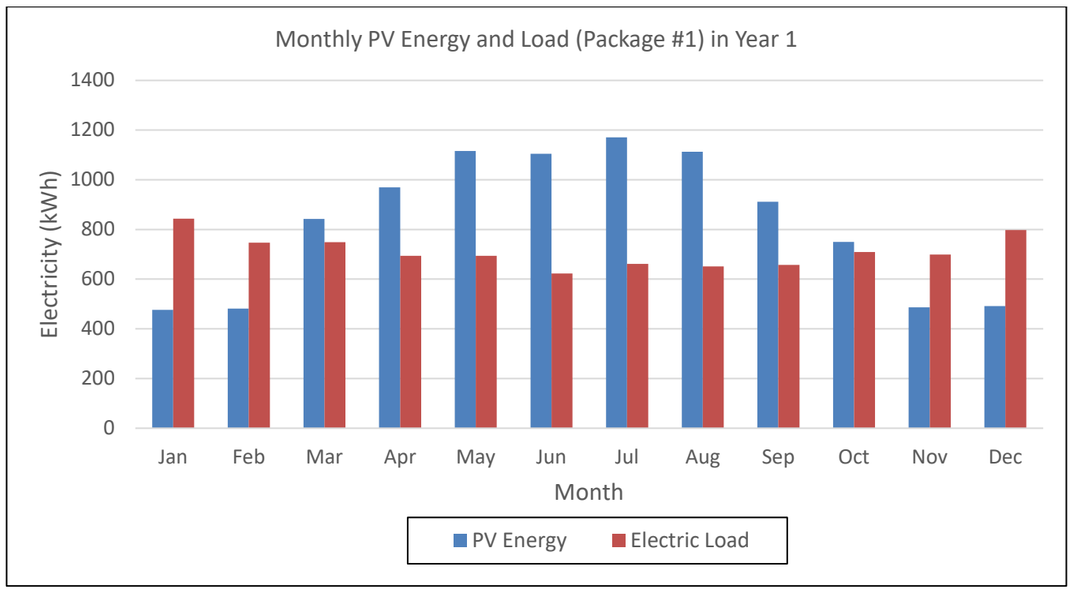
Rooftop Solar

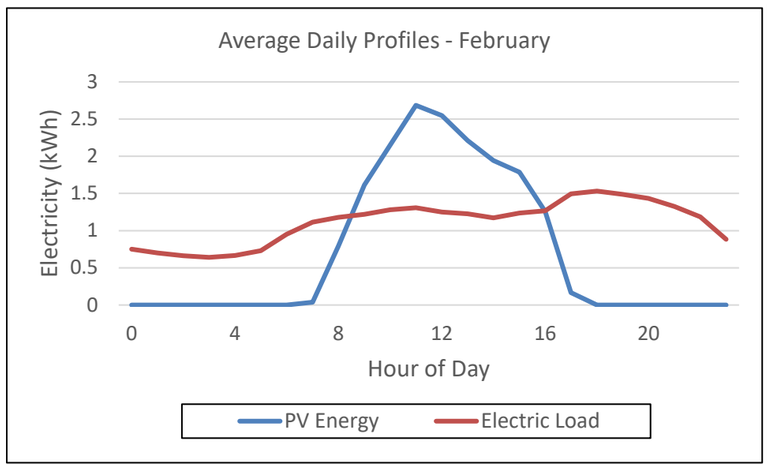
- Total PV generation (year 1): **9,915 kWh (1,525 kWh/kWdc)**
- Annual building electric load: **8,527 kWh**
- Total fraction of electric load met (year 1): **116.3%**
- Direct fraction of electric load met (year 1): **43.0%**
- Electricity cost without PV (year 1): $**2,444**
- Utility cost savings (w/ net metering) (year 1): **$2,868**
- Utility cost savings (w/o net metering) (year 1): **$1,097**
- System size: **6.5 kWdc**

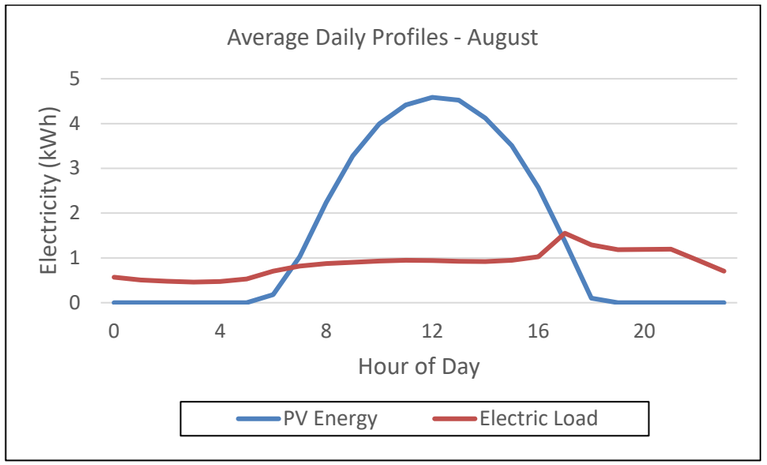
Annualized cost savings (w/ net metering): **$2,101**
Annualized cost savings (w/o net metering): **$330**

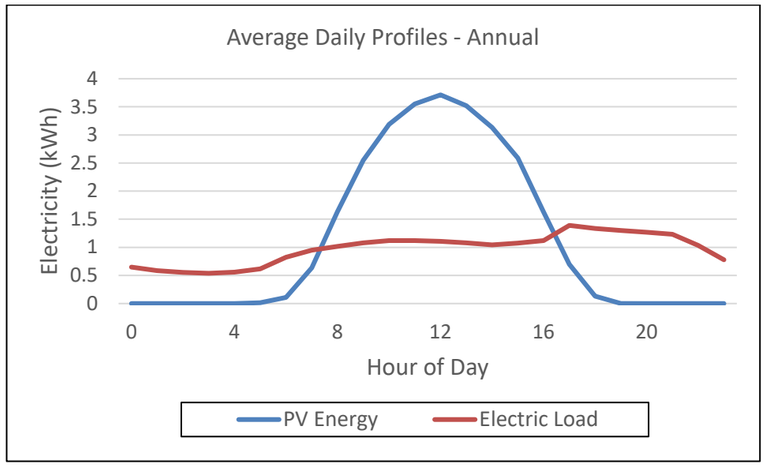
Solar Hot Water

- Estimated annual site energy savings: **21.4%**
- Utility cost savings: **$527/yr**
- Annualized cost savings: **-$55/yr**









5.11 Climate Zone 4A – White Cloud, KS (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 70°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Natural Gas Rate: $1.12/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.142
500–1000	$ 0.126
1000–1500	$ 0.118
1500+	$ 0.115

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.29, SHGC = 0.26	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 13
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	15.9%	15.5%	19.6%	19.8%	15.4%
	Ann. Energy Costs ($/yr)	2,148	1,929	1,932	1,945	1,949	2,000
	Ann. Energy Costs Savings (%)	0.0%	10.2%	10.0%	9.4%	9.2%	6.9%
	Source Energy Use (MMBtu/yr)	164.7	142.8	143.3	138.8	138.4	146.4

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

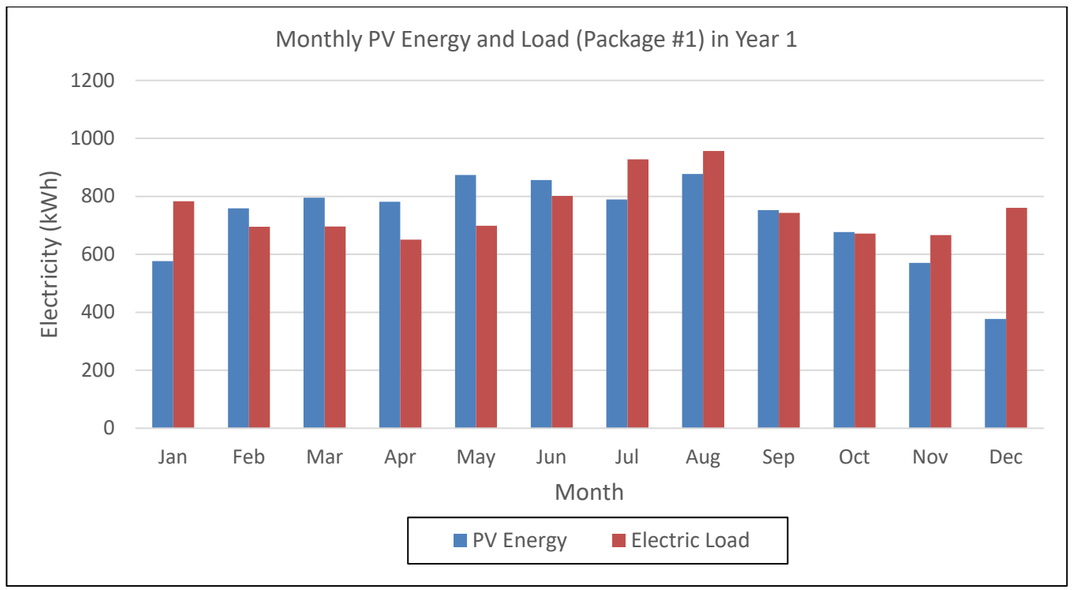
Rooftop Solar

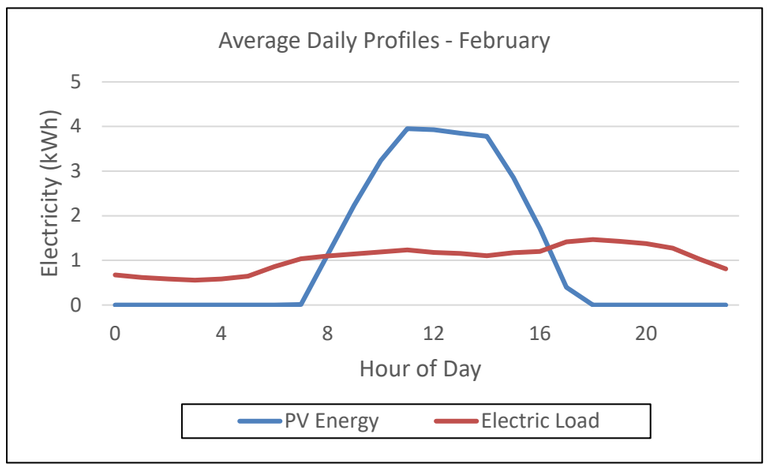
- Total PV generation (year 1): **8,686 kWh (1,336 kWh/kWdc)**
- Annual building electric load: **9,050 kWh**
- Total fraction of electric load met (year 1): **96.0%**
- Direct fraction of electric load met (year 1): **42.8%**
- Electricity cost without PV (year 1): $**1,236**
- Utility cost savings (w/ net metering) (year 1): **$1,185**
- Utility cost savings (w/o net metering) (year 1): **$502**
- System size: **6.5 kWdc**

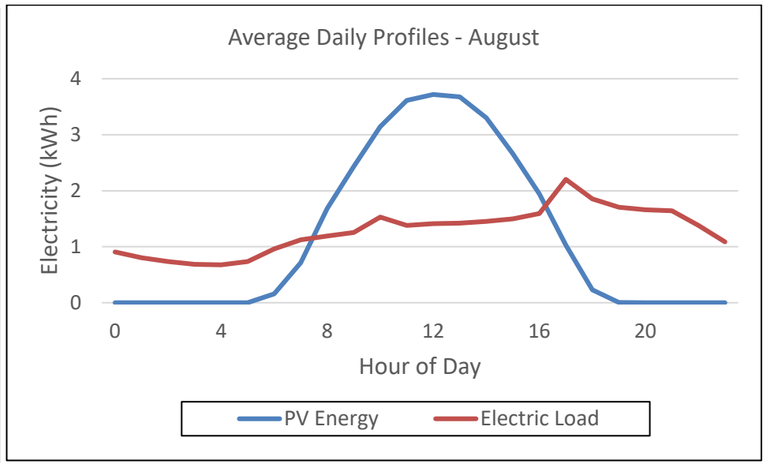
Annualized cost savings (w/ net metering): **$418**
Annualized cost savings (w/o net metering): **-$265**

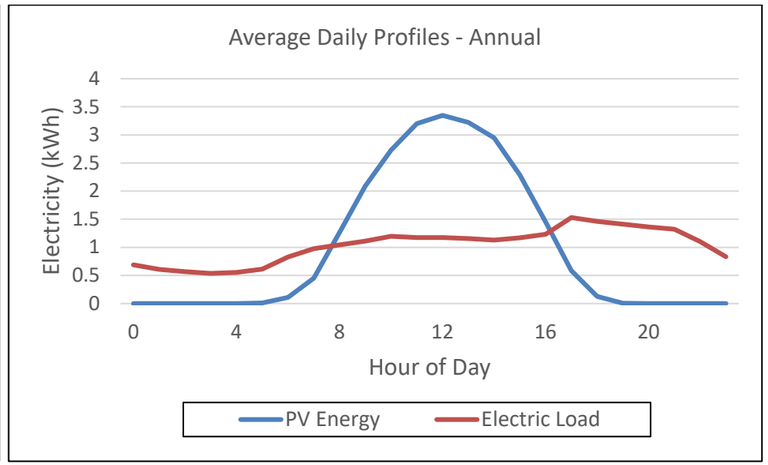
Solar Hot Water

- Estimated annual site energy savings: **16.2%**
- Utility cost savings: **$119/yr**
- Annualized cost savings: **-$463/yr**









5.12 Climate Zone 4A – White Cloud, KS (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 70°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Propane Rate: $2.76/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.142
500–1000	$ 0.126
1000–1500	$ 0.118
1500+	$ 0.115

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.21, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	HRV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 14	SEER 16 (2 Stage)	SEER 16
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 90% AFUE	Propane, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	22.6%	22.4%	25.3%	25.9%	25.7%
	Ann. Energy Costs ($/yr)	3,353	2,872	2,879	2,945	2,954	2,958
	Ann. Energy Costs Savings (%)	0.0%	14.3%	14.1%	12.2%	11.9%	11.8%
	Source Energy Use (MMBtu/yr)	170.9	144.	144.5	140.3	138.	138.7

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

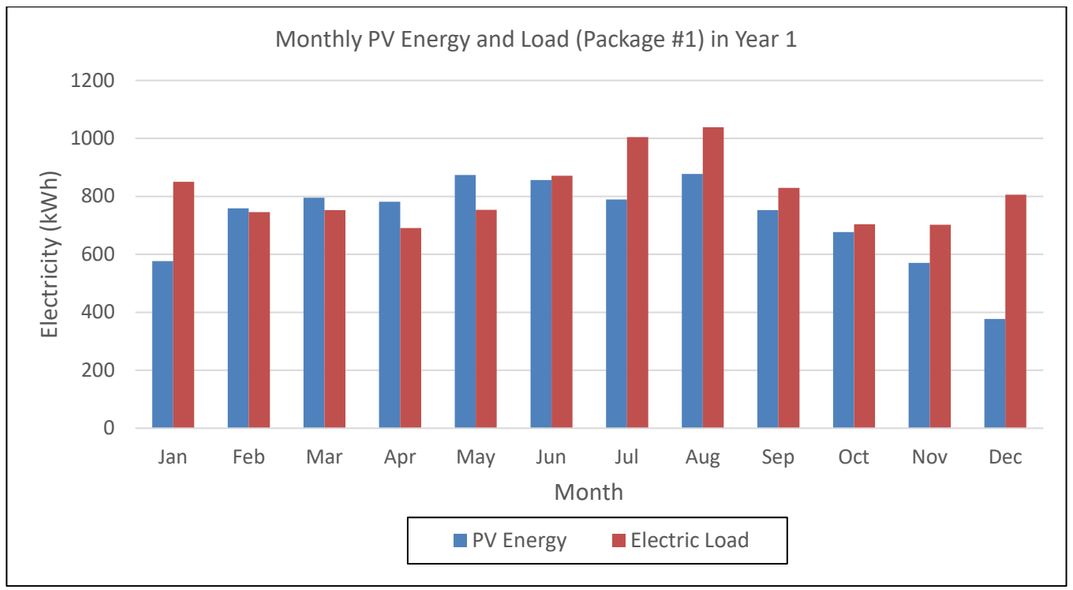
Rooftop Solar

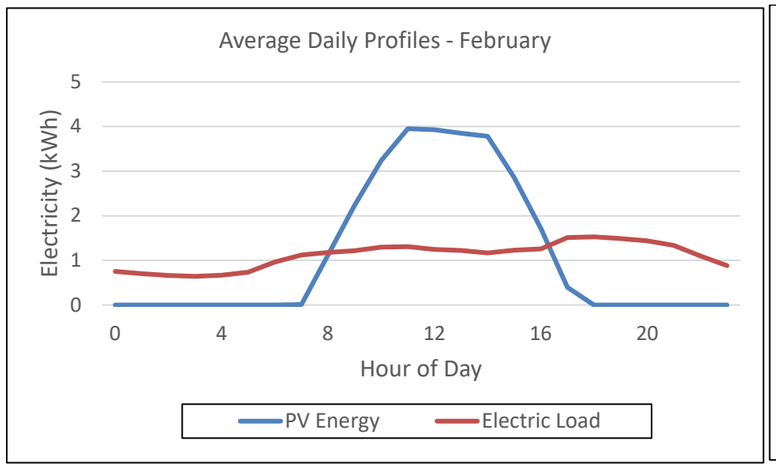
- Total PV generation (year 1): **8,686 kWh (1,336 kWh/kWdc)**
- Annual building electric load: **9,748 kWh**
- Total fraction of electric load met (year 1): **89.1%**
- Direct fraction of electric load met (year 1): **41.7%**
- Electricity cost without PV (year 1): $**1,324**
- Utility cost savings (w/ net metering) (year 1): **$1,177**
- Utility cost savings (w/o net metering) (year 1): **$522**
- System size: **6.5 kWdc**

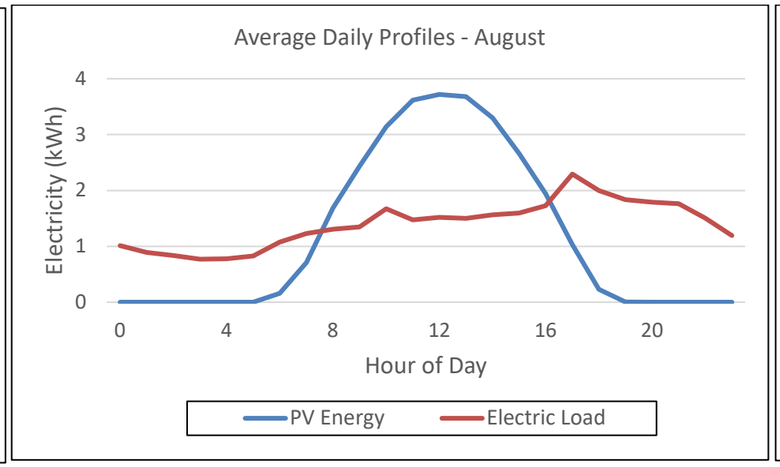
Annualized cost savings (w/ net metering): **$410**
Annualized cost savings (w/o net metering): **-$245**

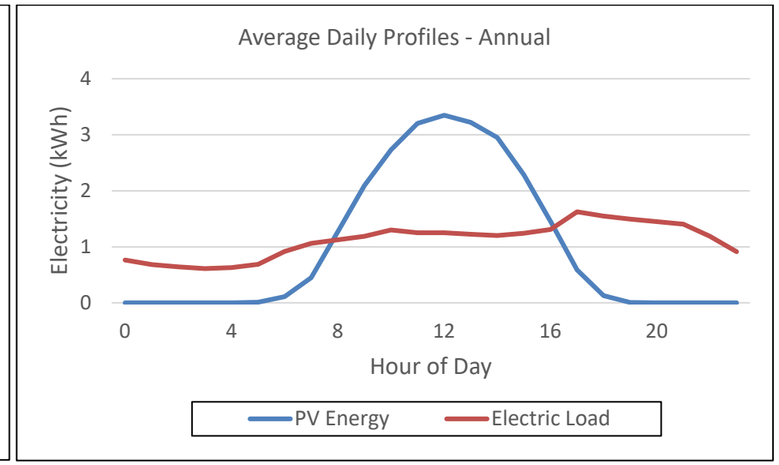
Solar Hot Water

- Estimated annual site energy savings: **17.3%**
- Utility cost savings: **$393/yr**
- Annualized cost savings: **-$189/yr**









5.13 Climate Zone 4B – San Fidel, NM (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Natural Gas Rate: $0.921/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.161
1000–1500	$ 0.158
1500+	$ 0.158

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-5 XPS	R-10 XPS	R-15 XPS	R-5 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.21, SHGC = 0.40	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	2 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Standard	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 24.5
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	14.3%	14.5%	17.4%	14.9%	14.5%
	Ann. Energy Costs ($/yr)	2,129	1,990	1,992	2,019	2,028	2,066
	Ann. Energy Costs Savings (%)	0.0%	6.5%	6.4%	5.2%	4.8%	3.0%
	Source Energy Use (MMBtu/yr)	148.2	131.	130.9	128.	130.9	128.7

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

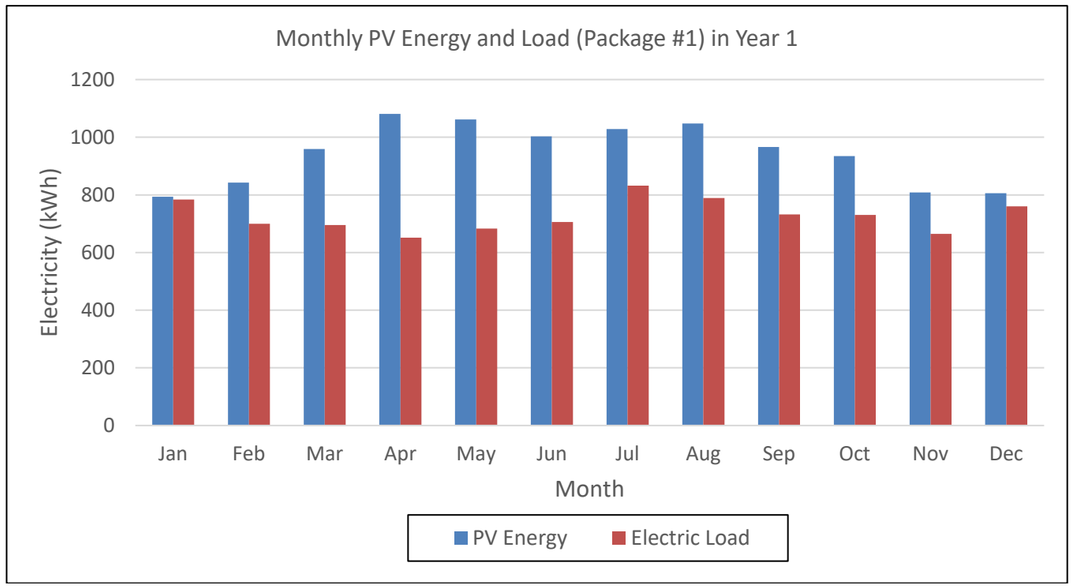
Rooftop Solar

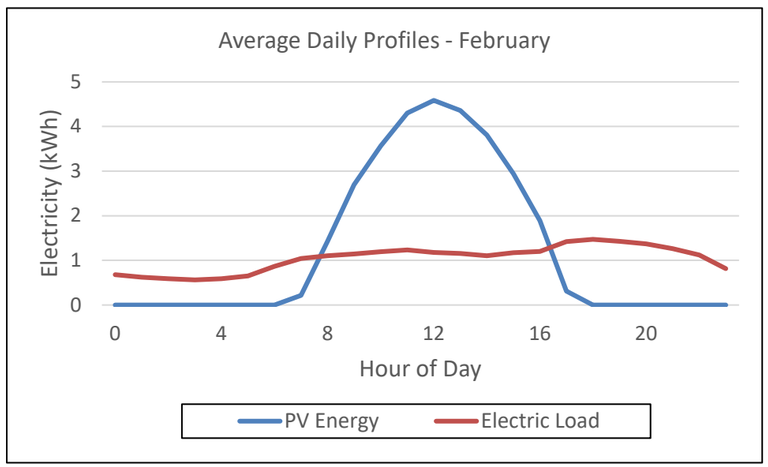
- Total PV generation (year 1): **11,331 kWh (1,743 kWh/kWdc)**
- Annual building electric load: **8,729 kWh**
- Total fraction of electric load met (year 1): **129.8%**
- Direct fraction of electric load met (year 1): **46.0%**
- Electricity cost without PV (year 1): $**1,471**
- Utility cost savings (w/ net metering) (year 1): **$1,904**
- Utility cost savings (w/o net metering) (year 1): **$661**
- System size: **6.5 kWdc**

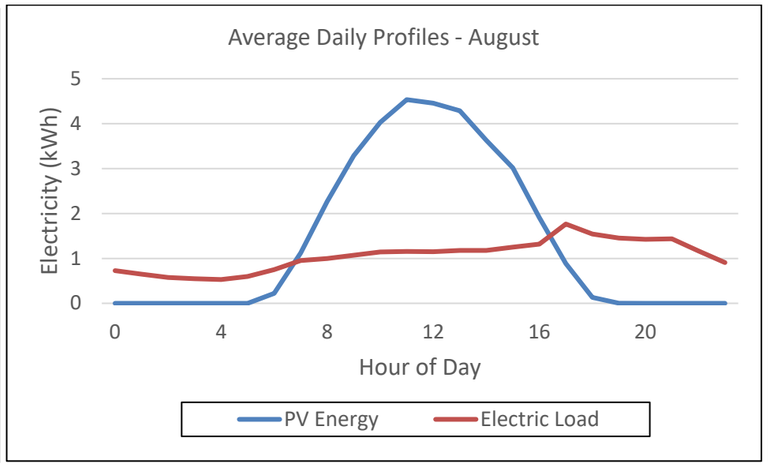
Annualized cost savings (w/ net metering): **$1,137**
Annualized cost savings (w/o net metering): **-$106**

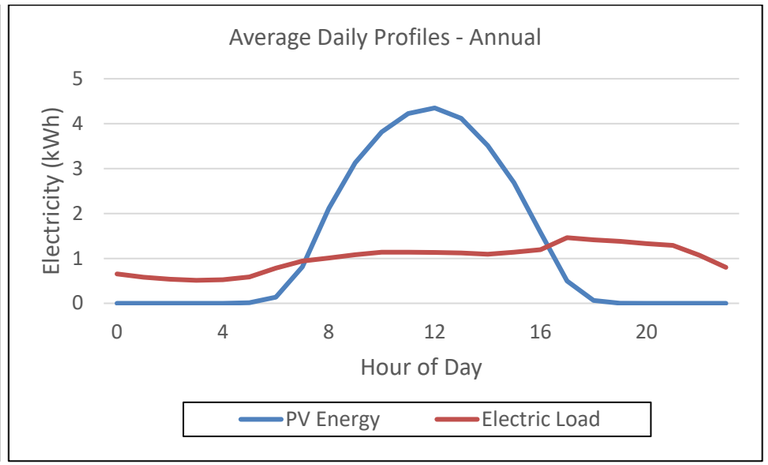
Solar Hot Water

- Estimated annual site energy savings: **22.8%**
- Utility cost savings: **$106/yr**
- Annualized cost savings: **-$476/yr**









5.14 Climate Zone 4B – San Fidel, NM (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 71°F
Cooling Setpoint: 72°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.161
1000–1500	$ 0.158
1500+	$ 0.158

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	3 ACH50	3 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	HRV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 18, 9.3 HSPF	SEER 19, 9.5 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 18, 9.3 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	33.0%	33.3%	34.9%	34.9%	32.3%
	Ann. Energy Costs ($/yr)	3,387	2,704	2,711	2,785	2,785	2,811
	Ann. Energy Costs Savings (%)	0.0%	20.2%	20.0%	17.8%	17.8%	17.0%
	Source Energy Use (MMBtu/yr)	193.4	121.3	120.6	117.6	117.7	122.6

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

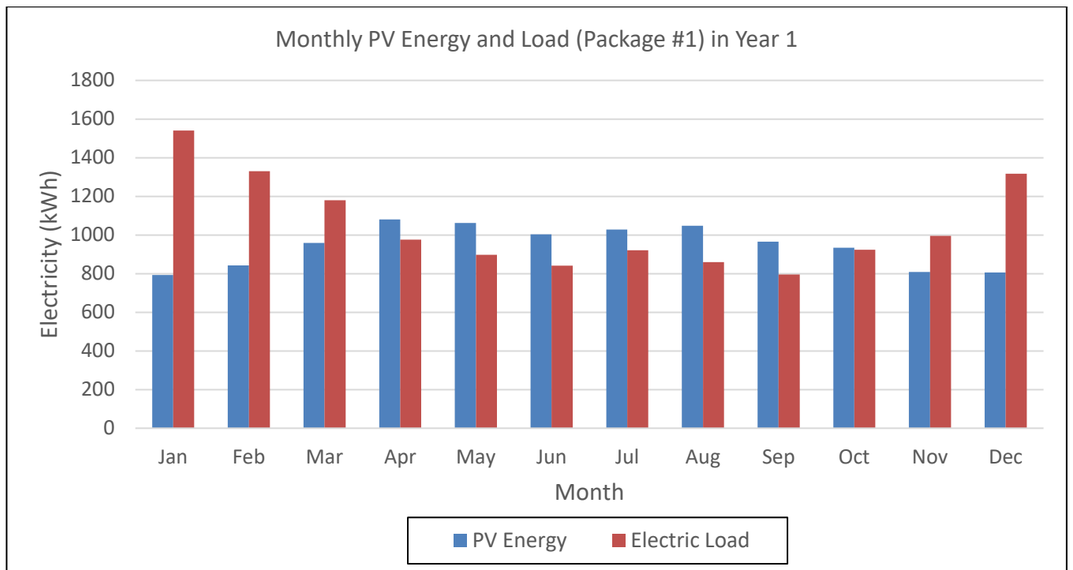
Rooftop Solar

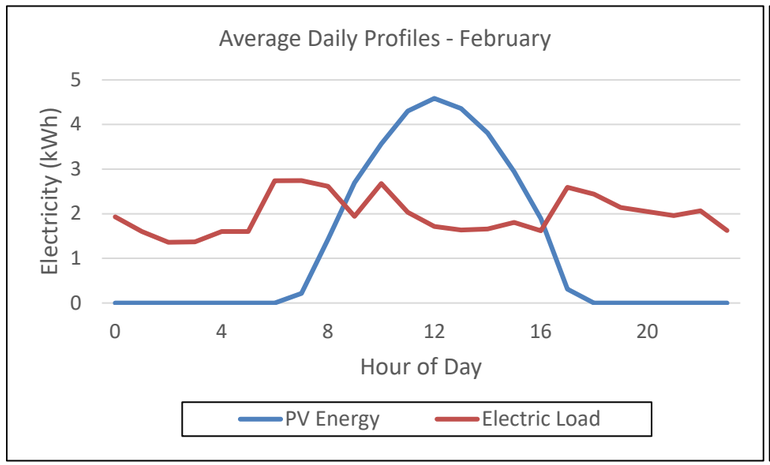
- Total PV generation (year 1): **11,331 kWh (1,743 kWh/kWdc)**
- Annual building electric load: **12,581 kWh**
- Total fraction of electric load met (year 1): **90.1%**
- Direct fraction of electric load met (year 1): **40.4%**
- Electricity cost without PV (year 1): $**2,087**
- Utility cost savings (w/ net metering) (year 1): **$1,884**
- Utility cost savings (w/o net metering) (year 1): **$817**
- System size: **6.5 kWdc**

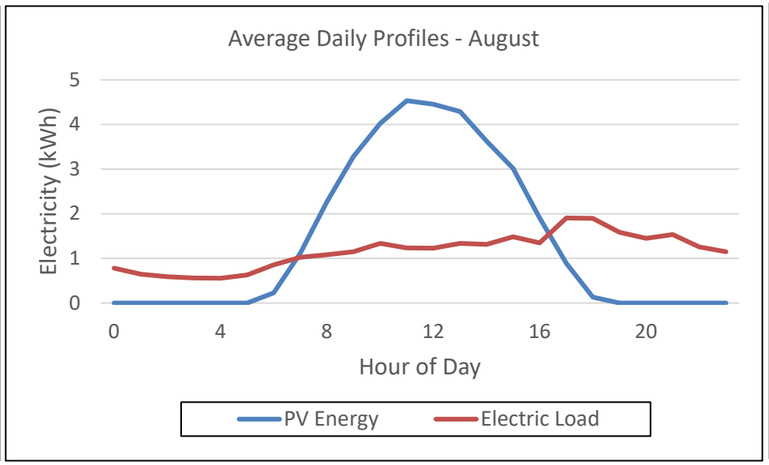
Annualized cost savings (w/ net metering): **$1,117**
Annualized cost savings (w/o net metering): **$50**

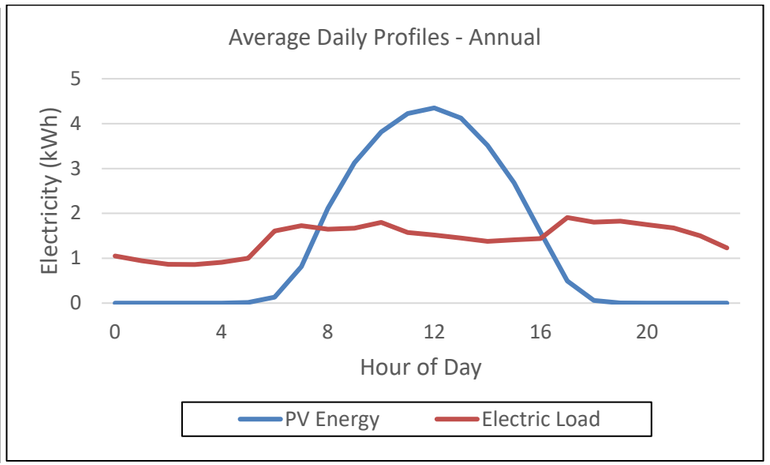
Solar Hot Water

- Estimated annual site energy savings: **7.6%**
- Utility cost savings: **$172/yr**
- Annualized cost savings: **-$410/yr**









5.15 Climate Zone 4C – Salem, OR (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Vented Crawlspace
Natural Gas Rate: $1.02/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.124
500–1000	$ 0.109
1000–1500	$ 0.108
1500+	$ 0.107

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-5 XPS	R-10 XPS	R-15 XPS	R-10 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Crawlspace	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented
	Windows	U = 0.30, SHGC = 0.38	U = 0.29, SHGC = 0.26	U = 0.29, SHGC = 0.26	U = 0.29, SHGC = 0.26	U = 0.27, SHGC = 0.26	U = 0.29, SHGC = 0.26
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	1 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 13	SEER 13
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 80% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	10.3%	10.5%	10.4%	11.7%	12.4%
	Ann. Energy Costs ($/yr)	1,615	1,446	1,448	1,453	1,453	1,463
	Ann. Energy Costs Savings (%)	0.0%	10.4%	10.3%	10.0%	10.0%	9.4%
	Source Energy Use (MMBtu/yr)	137.0	126.9	126.8	126.8	125.7	125.2

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

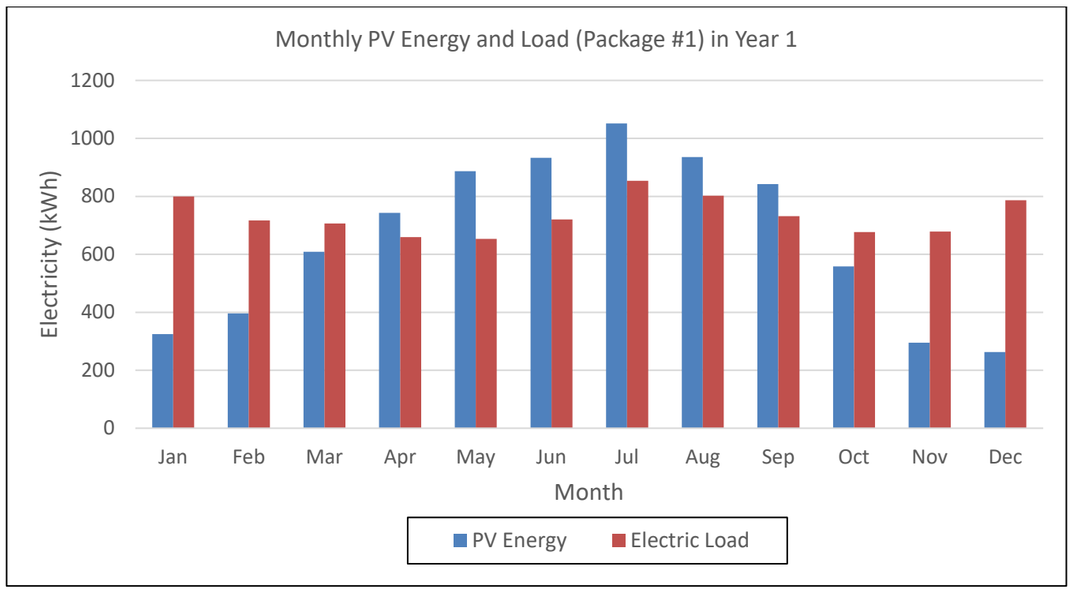
Rooftop Solar

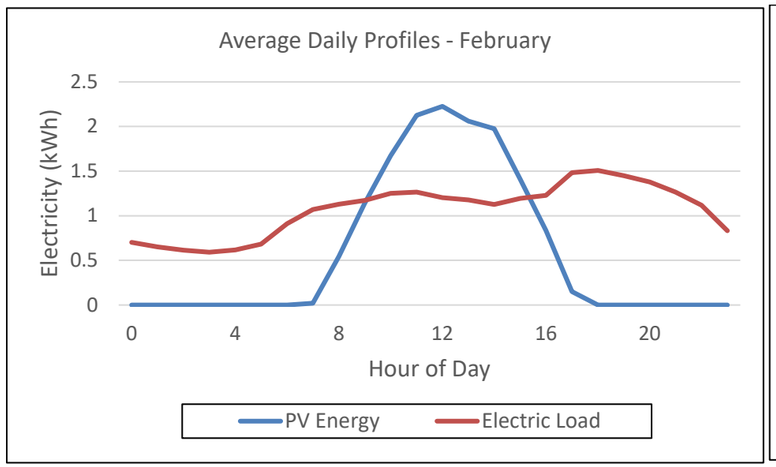
- Total PV generation (year 1): **7,838 kWh (1,206 kWh/kWdc)**
- Annual building electric load: **8,785 kWh**
- Total fraction of electric load met (year 1): **89.2%**
- Direct fraction of electric load met (year 1): **41.1%**
- Electricity cost without PV (year 1): $**1,048**
- Utility cost savings (w/ net metering) (year 1): **$930**
- Utility cost savings (w/o net metering) (year 1): **$409**
- System size: **6.5 kWdc**

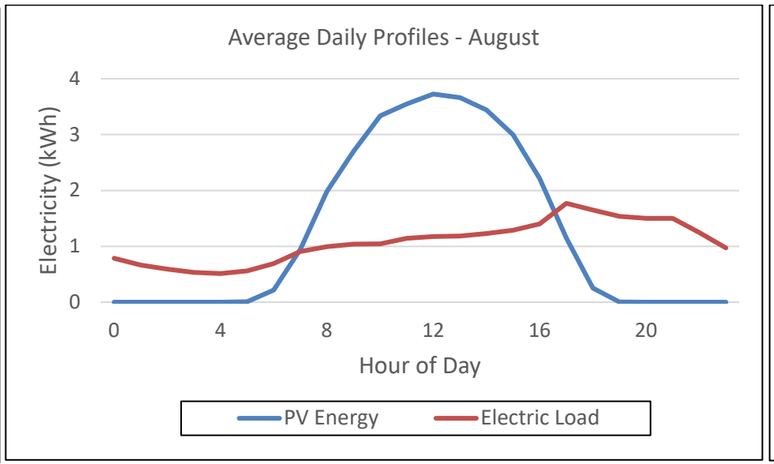
Annualized cost savings (w/ net metering): **$163**
Annualized cost savings (w/o net metering): **-$358**

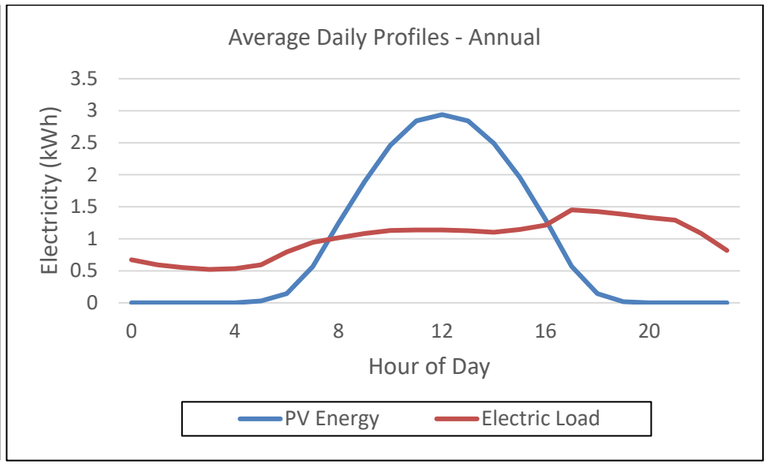
Solar Hot Water

- Estimated annual site energy savings: **16.0%**
- Utility cost savings: **$92/yr**
- Annualized cost savings: **-$491/yr**









5.16 Climate Zone 4C – Salem, OR (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Vented Crawlspace
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.124
500–1000	$ 0.109
1000–1500	$ 0.108
1500+	$ 0.107

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-13 Fiberglass, 2x4, 16"	R-15 Fiberglass, 2x4, 16"	R-15 Fiberglass, 2x4, 16"
	Wall Sheathing	R-10 XPS	R-5 XPS	R-5 XPS	R-10 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Crawlspace	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented	R-30 Fiberglass, Vented
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.29, SHGC = 0.26	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	2 ACH50	2 ACH50	1 ACH50	3 ACH50	3 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 14, 8.2 HSPF	SEER 14, 8.2 HSPF	SEER 14, 8.2 HSPF	SEER 14, 8.2 HSPF	SEER 15, 8.5 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	12.3%	12.3%	12.5%	12.4%	12.5%
	Ann. Energy Costs ($/yr)	2,178	1,932	1,935	1,937	1,939	1,948
	Ann. Energy Costs Savings (%)	0.0%	11.3%	11.2%	11.1%	11.0%	10.6%
	Source Energy Use (MMBtu/yr)	173.1	150.8	150.8	150.5	150.5	150.5

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

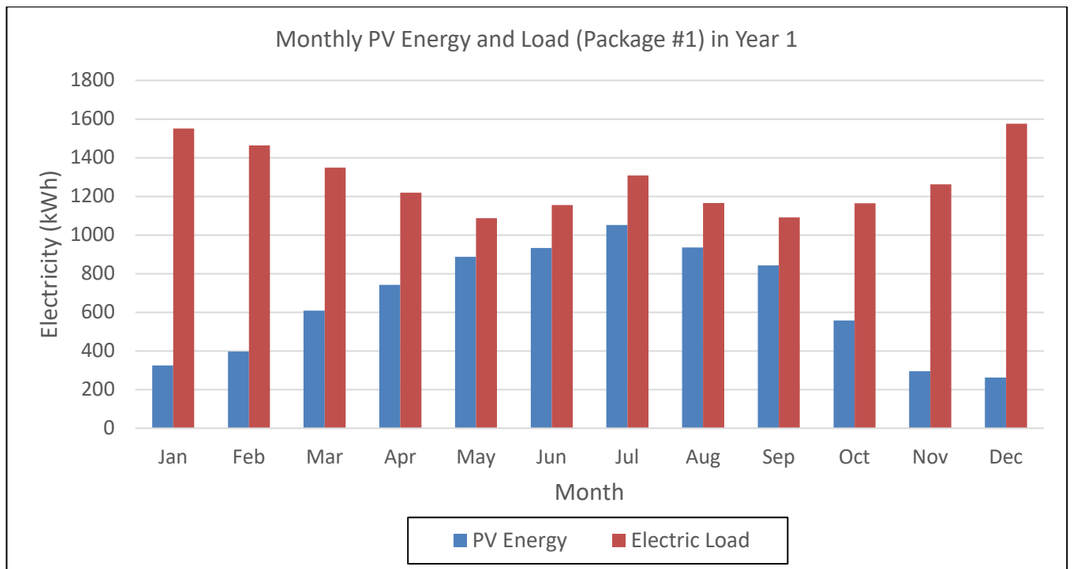
Rooftop Solar

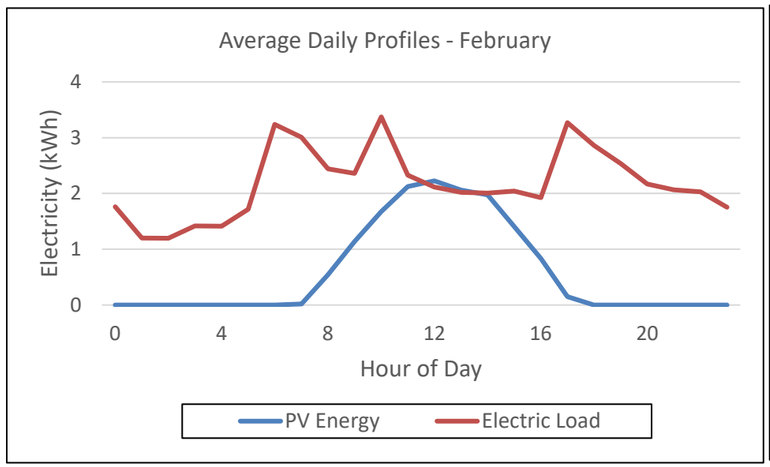
- Total PV generation (year 1): **7,838 kWh (1,206 kWh/kWdc)**
- Annual building electric load: **15,390 kWh**
- Total fraction of electric load met (year 1): **50.9%**
- Direct fraction of electric load met (year 1): **31.7%**
- Electricity cost without PV (year 1): $**1,764**
- Utility cost savings (w/ net metering) (year 1): **$896**
- Utility cost savings (w/o net metering) (year 1): **$529**
- System size: **6.5 kWdc**

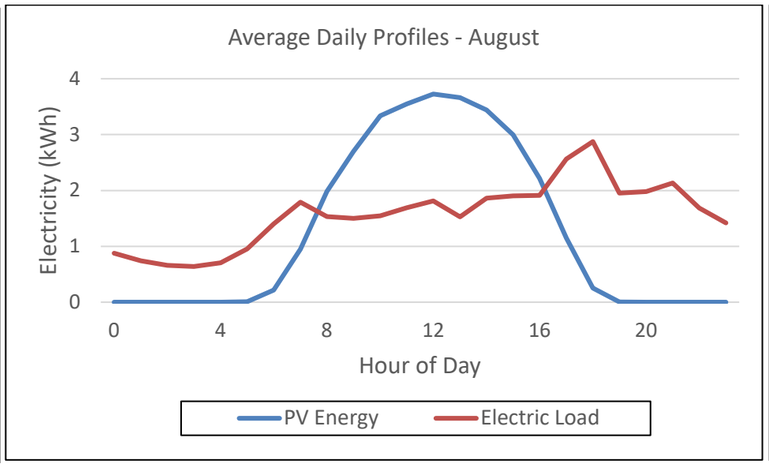
Annualized cost savings (w/ net metering): **$129**
Annualized cost savings (w/o net metering): **-$238**

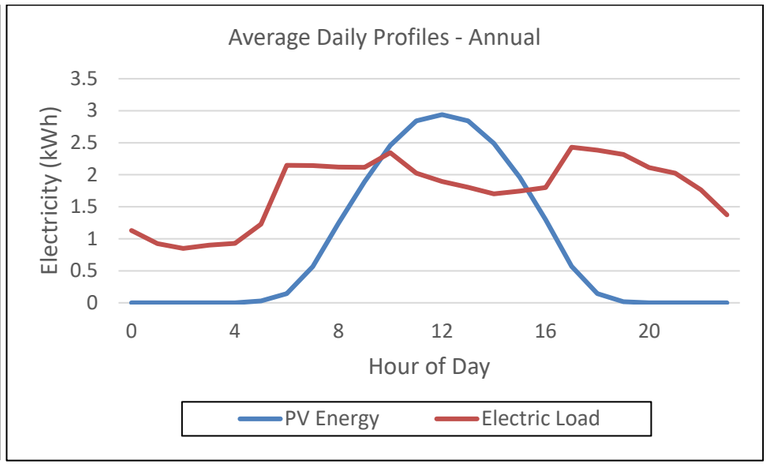
Solar Hot Water

- Estimated annual site energy savings: **13.8%**
- Utility cost savings: **$261/yr**
- Annualized cost savings: **-$320/yr**









5.17 Climate Zone 5A – Rosebud, SD (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 70°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Electricity Rate: $0.10/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.21, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 14, 8.2 HSPF	SEER 15, 8.5 HSPF	SEER 15, 8.5 HSPF	SEER 15, 8.5 HSPF	SEER 14, 8.2 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	27.7%	28.2%	27.5%	27.8%	27.6%
	Ann. Energy Costs ($/yr)	2,705	1,950	1,954	1,955	1,959	1,980
	Ann. Energy Costs Savings (%)	0.0%	27.9%	27.8%	27.7%	27.6%	26.8%
	Source Energy Use (MMBtu/yr)	255.8	182.7	181.3	183.1	182.3	183.

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

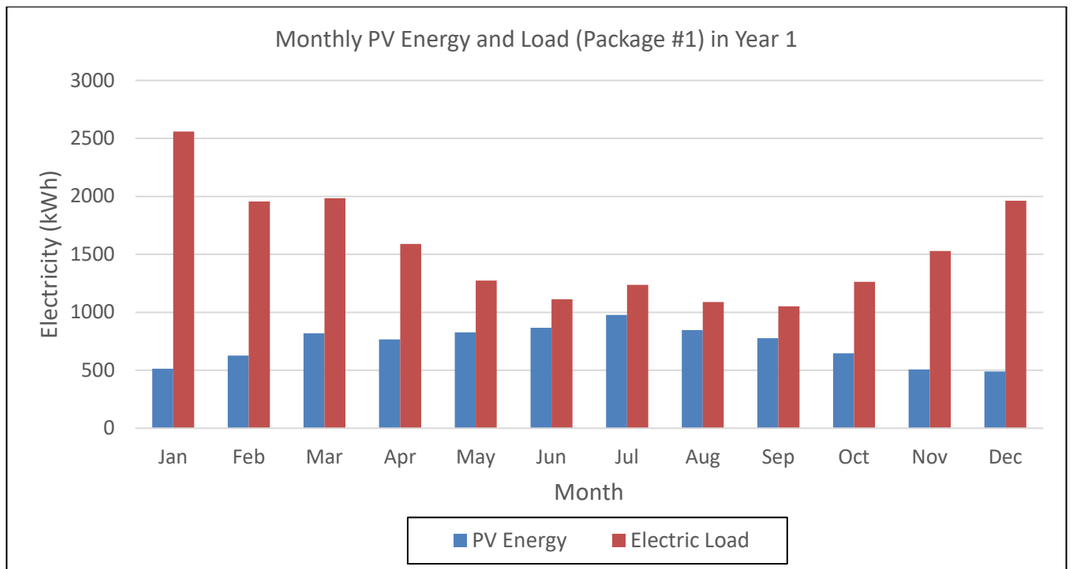
Rooftop Solar

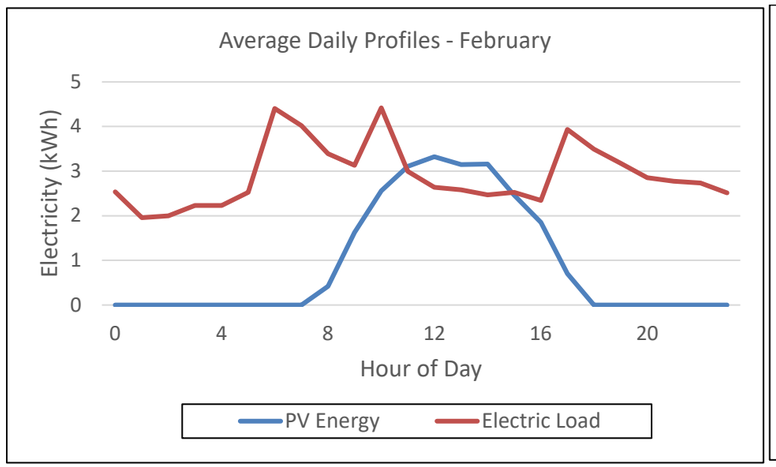
- Total PV generation (year 1): **8,661 kWh (1,332 kWh/kWdc)**
- Annual building electric load: **18,605 kWh**
- Total fraction of electric load met (year 1): **46.6%**
- Direct fraction of electric load met (year 1): **29.3%**
- Electricity cost without PV (year 1): $**1,861**
- Utility cost savings (w/ net metering) (year 1): **$866**
- Utility cost savings (w/o net metering) (year 1): **$545**
- System size: **6.5 kWdc**

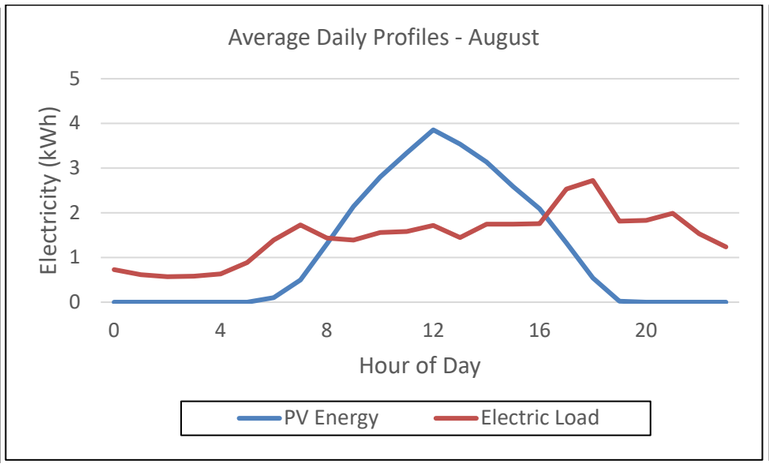
Annualized cost savings (w/ net metering): **$99**
Annualized cost savings (w/o net metering): **-$222**

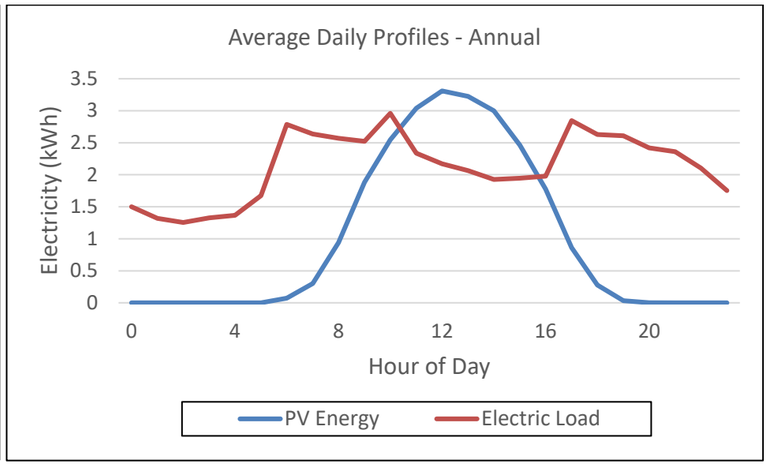
Solar Hot Water

- Estimated annual site energy savings: **14.6%**
- Utility cost savings: **$292/yr**
- Annualized cost savings: **-$289/yr**









5.18 Climate Zone 5A – Rosebud, SD (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 70°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Propane Rate: $2.20/gal
Electricity Rate: $0.10/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.21, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 13	SEER 13
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 90% AFUE	Propane, 94% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	21.8%	21.1%	25.2%	24.9%	26.4%
	Ann. Energy Costs ($/yr)	2,887	2,490	2,501	2,534	2,540	2,580
	Ann. Energy Costs Savings (%)	0.0%	13.7%	13.4%	12.2%	12.0%	10.6%
	Source Energy Use (MMBtu/yr)	173.4	147.4	148.3	143.5	143.9	142.1

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

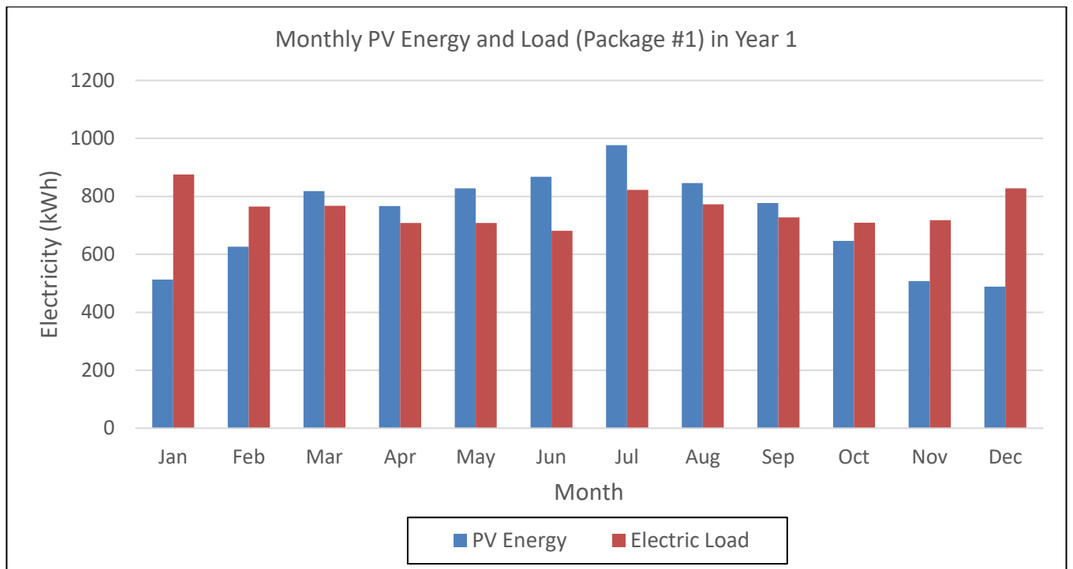
Rooftop Solar

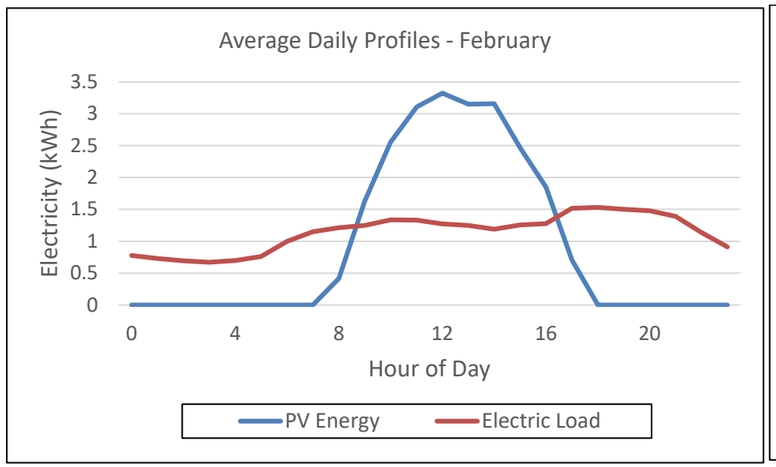
- Total PV generation (year 1): **8,661 kWh (1,332 kWh/kWdc)**
- Annual building electric load: **9,082 kWh**
- Total fraction of electric load met (year 1): **95.4%**
- Direct fraction of electric load met (year 1): **41.9%**
- Electricity cost without PV (year 1): **$908**
- Utility cost savings (w/ net metering) (year 1): **$866**
- Utility cost savings (w/o net metering) (year 1): **$527**
- System size: **6.5 kWdc**

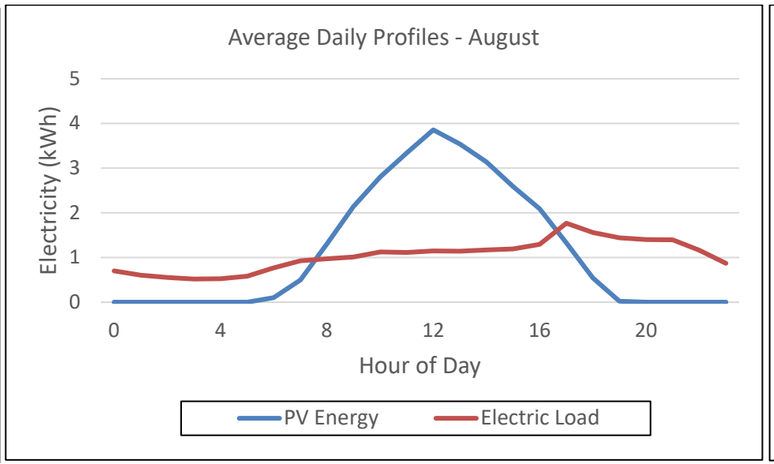
Annualized cost savings (w/ net metering): **$99**
Annualized cost savings (w/o net metering): **-$240**

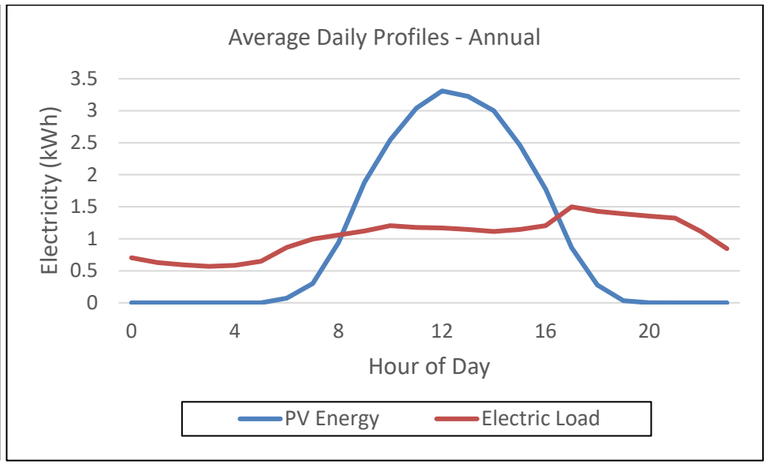
Solar Hot Water

- Estimated annual site energy savings: **16.5%**
- Utility cost savings: **$354/yr**
- Annualized cost savings: **-$228/yr**









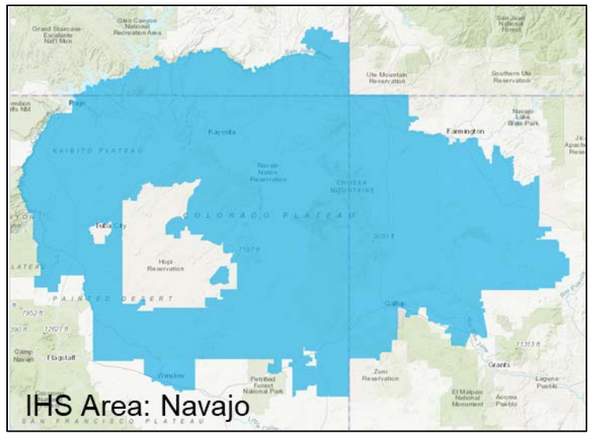
5.19 Climate Zone 5B – Window Rock, AZ (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.173
1000–1500	$ 0.174
1500+	$ 0.175



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 18, 9.3 HSPF	SEER 19, 9.5 HSPF	SEER 18, 9.3 HSPF	SEER 19, 9.5 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	39.7%	40.1%	39.2%	42.1%	42.2%
	Ann. Energy Costs ($/yr)	3,890	2,901	2,907	2,939	2,985	3,012
	Ann. Energy Costs Savings (%)	0.0%	25.4%	25.3%	24.5%	23.3%	22.6%
	Source Energy Use (MMBtu/yr)	215.3	129.8	129.1	130.9	124.8	124.5

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

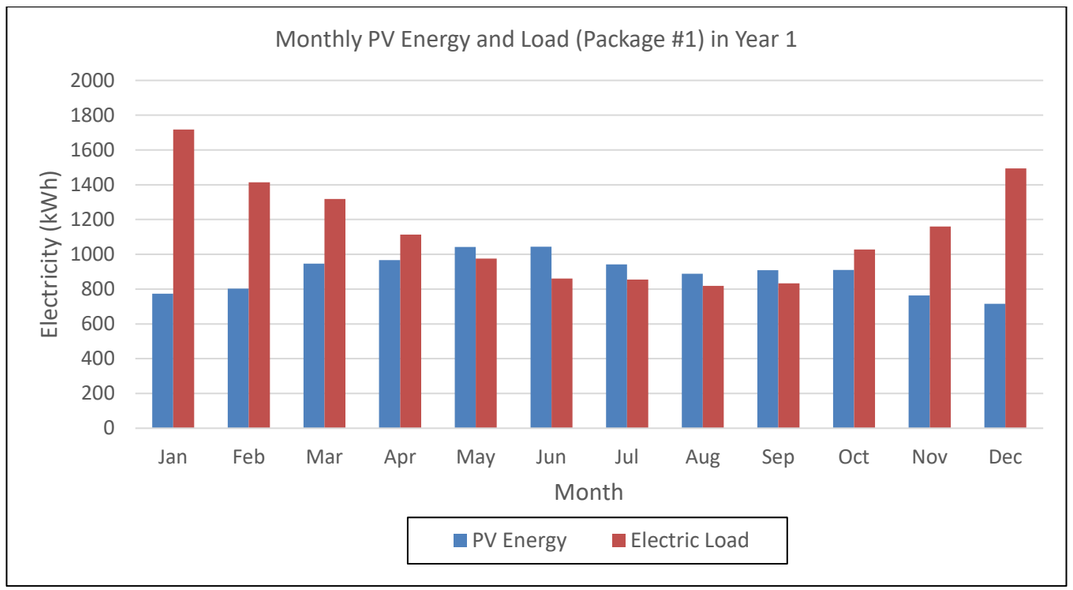
Rooftop Solar

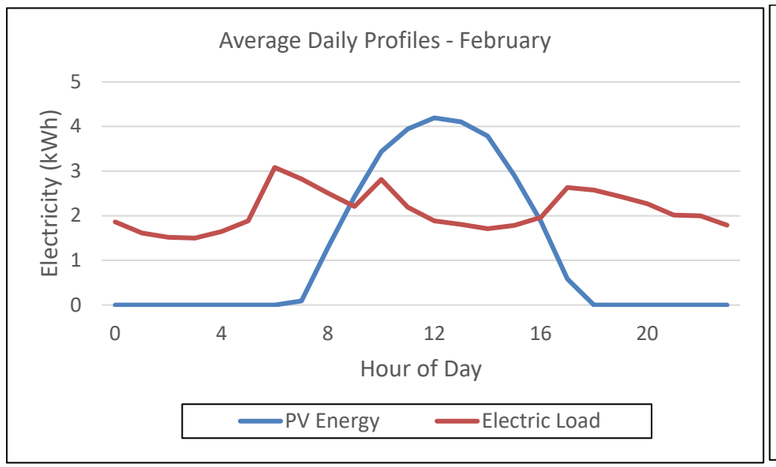
- Total PV generation (year 1): **10,702 kWh (1,646 kWh/kWdc)**
- Annual building electric load: **13,589 kWh**
- Total fraction of electric load met (year 1): **78.8%**
- Direct fraction of electric load met (year 1): **38.3%**
- Electricity cost without PV (year 1): $**2,347**
- Utility cost savings (w/ net metering) (year 1): **$1,848**
- Utility cost savings (w/o net metering) (year 1): **$902**
- System size: **6.5 kWdc**

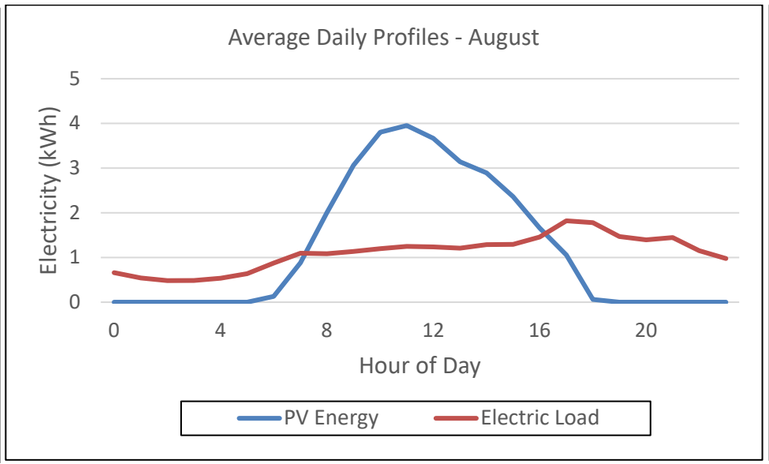
Annualized cost savings (w/ net metering): **$1,081**
Annualized cost savings (w/o net metering): **$135**

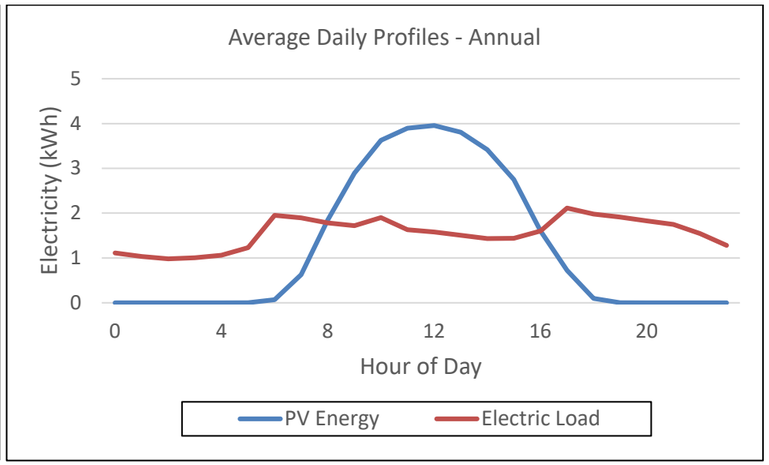
Solar Hot Water

- Estimated annual site energy savings: **9.1%**
- Utility cost savings: **$212/yr**
- Annualized cost savings: **-$370/yr**









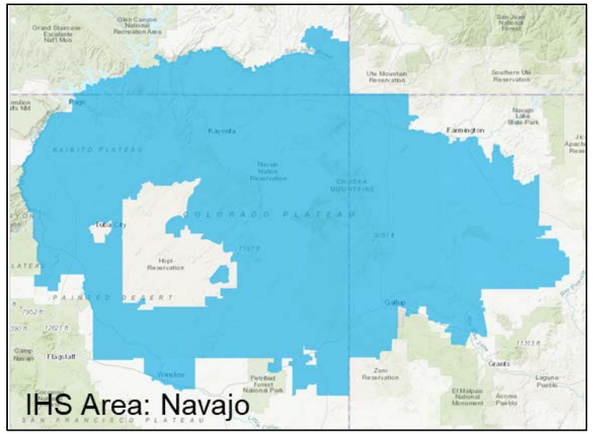
5.20 Climate Zone 5B – Window Rock, AZ (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Propane Rate: $3.67/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.173
1000–1500	$ 0.174
1500+	$ 0.175



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	HRV, 70% SRE	HRV, 70% SRE	ERV, 70% SRE	HRV, 70% SRE	HRV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 13
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 90% AFUE	Propane, 94% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	21.3%	20.9%	24.5%	24.1%	22.5%
	Ann. Energy Costs ($/yr)	4,140	3,538	3,550	3,605	3,614	3,656
	Ann. Energy Costs Savings (%)	0.0%	14.5%	14.2%	12.9%	12.7%	11.7%
	Source Energy Use (MMBtu/yr)	154.8	134.8	135.2	130.3	130.8	133.4

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

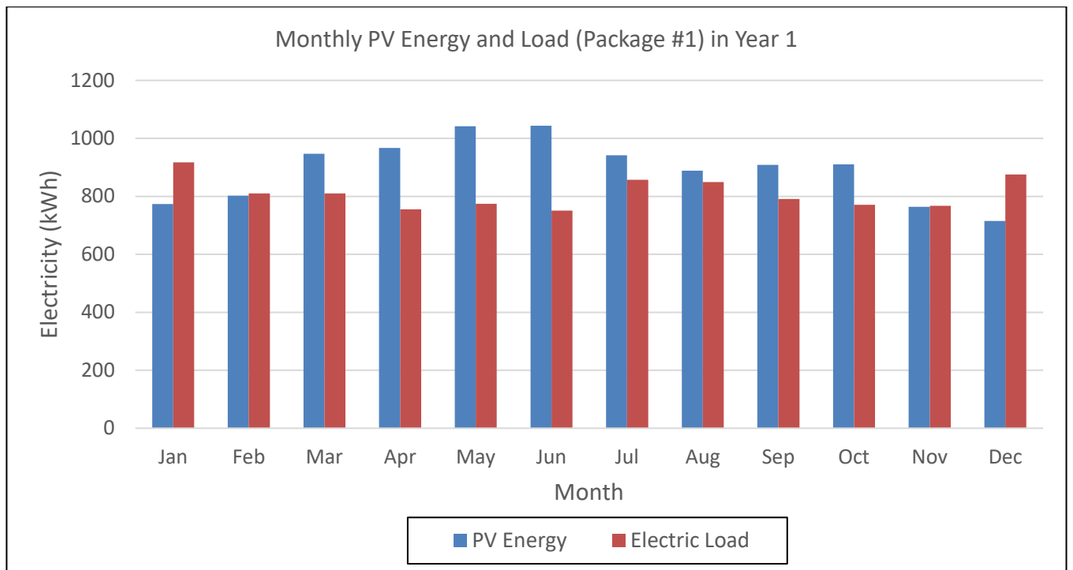
Rooftop Solar

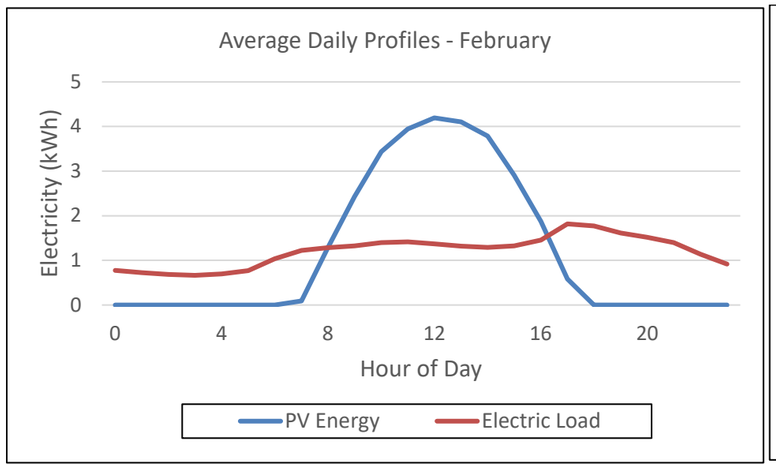
- Total PV generation (year 1): **10,702 kWh (1,646 kWh/kWdc)**
- Annual building electric load: **9,729 kWh**
- Total fraction of electric load met (year 1): **110%**
- Direct fraction of electric load met (year 1): **44.6%**
- Electricity cost without PV (year 1): $**1,677**
- Utility cost savings (w/ net metering) (year 1): **$1,845**
- Utility cost savings (w/o net metering) (year 1): **$750**
- System size: **6.5 kWdc**

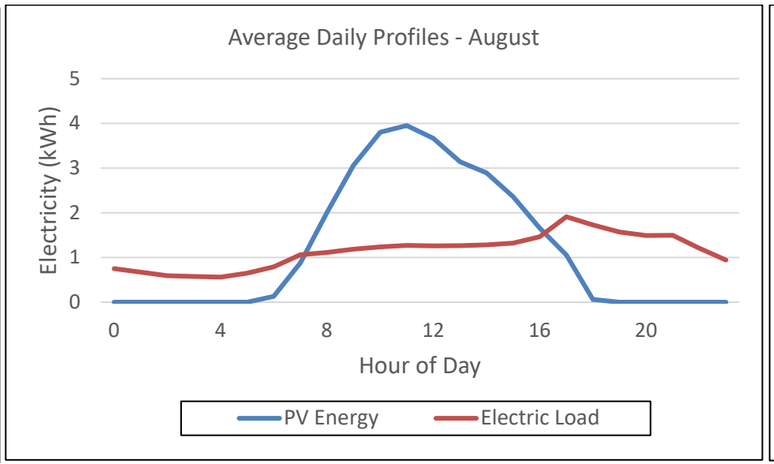
Annualized cost savings (w/ net metering): **$1,078**
Annualized cost savings (w/o net metering): **-$17**

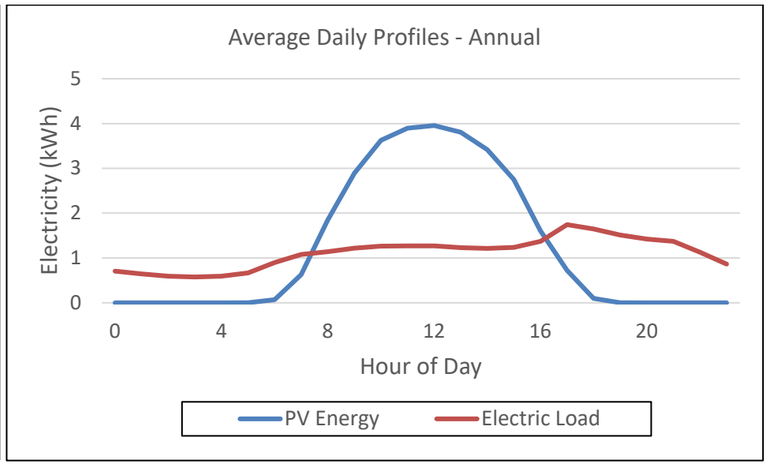
Solar Hot Water

- Estimated annual site energy savings: **24.8%**
- Utility cost savings: **$729/yr**
- Annualized cost savings: **$147/yr**









5.21 Climate Zone 5B – Warm Springs, OR (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Natural Gas Rate: $1.02/therm
Electricity Rate: $0.096/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-10 XPS	R-5 XPS	R-10 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.21, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 14	SEER 13
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	12.0%	12.2%	13.4%	12.6%	12.5%
	Ann. Energy Costs ($/yr)	1,717	1,429	1,432	1,443	1,446	1,452
	Ann. Energy Costs Savings (%)	0.0%	16.8%	16.6%	16.0%	15.8%	15.4%
	Source Energy Use (MMBtu/yr)	173.9	158.1	157.8	156.6	157.3	157.6

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

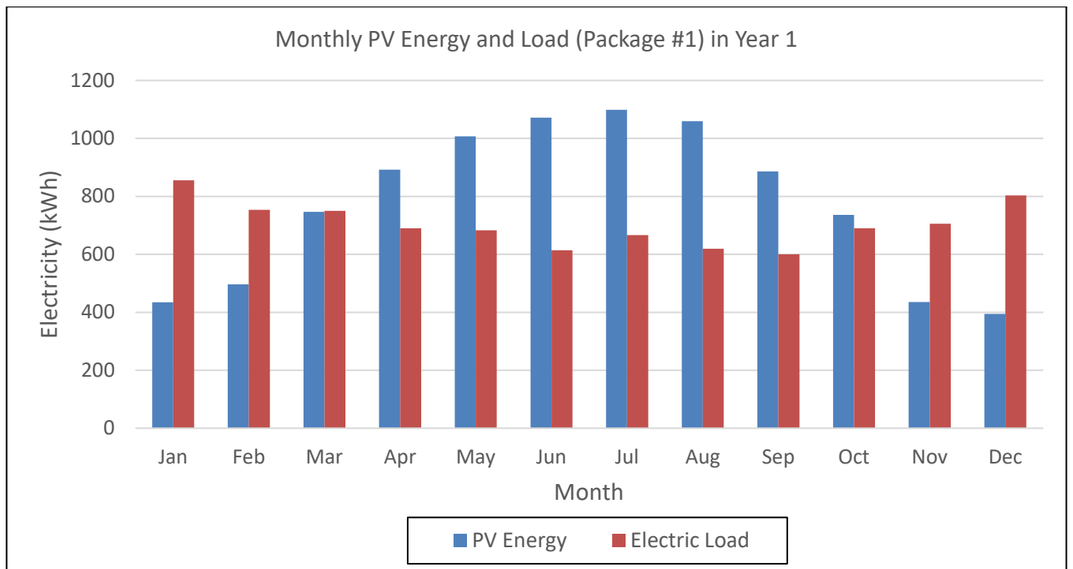
Rooftop Solar

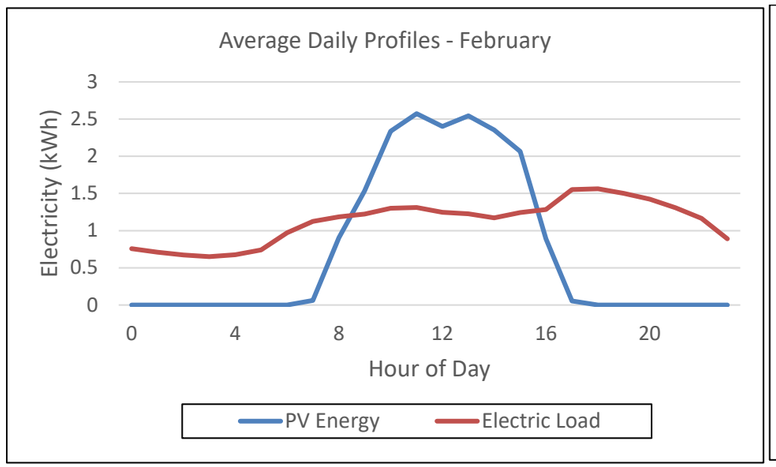
- Total PV generation (year 1): **9,258 kWh (1,424 kWh/kWdc)**
- Annual building electric load: **8,431 kWh**
- Total fraction of electric load met (year 1): **109.8%**
- Direct fraction of electric load met (year 1): **42.9%**
- Electricity cost without PV (year 1): $**809**
- Utility cost savings (w/ net metering) (year 1): **$889**
- Utility cost savings (w/o net metering) (year 1): **$347**
- System size: **6.5 kWdc**

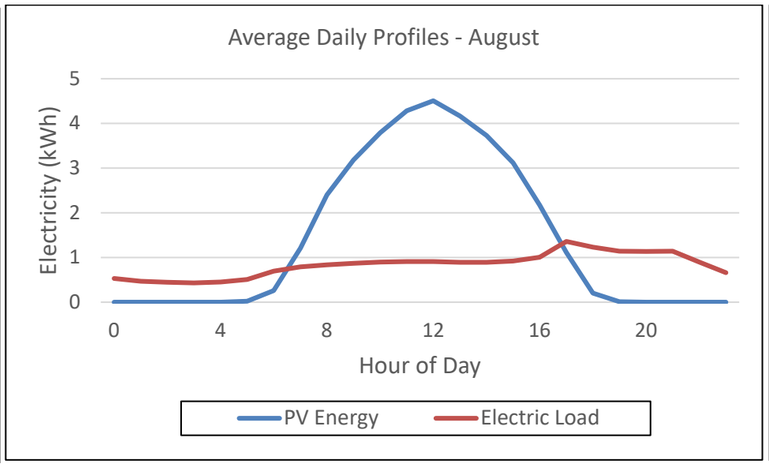
Annualized cost savings (w/ net metering): **$122**
Annualized cost savings (w/o net metering): **-$420**

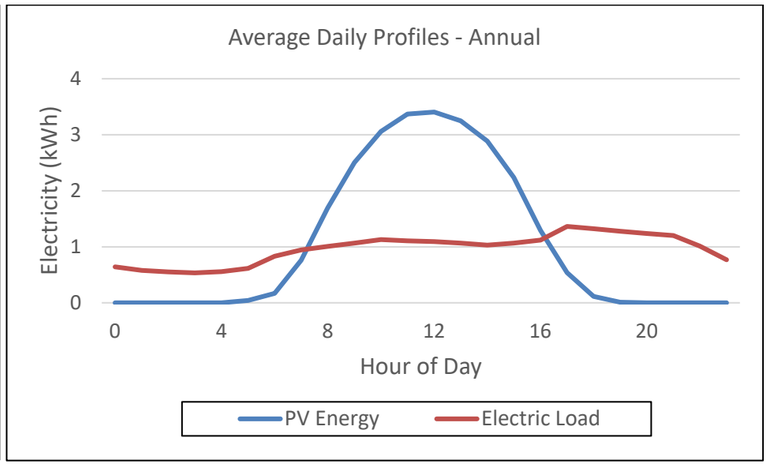
Solar Hot Water

- Estimated annual site energy savings: **16.0%**
- Utility cost savings: **$154/yr**
- Annualized cost savings: **-$427/yr**









5.22 Climate Zone 5B – Warm Springs, OR (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Electricity Rate: $0.096/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-5 XPS	R-10 XPS	R-10 XPS	R-5 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R10 Exterior XPS	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.21, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	2 ACH50	1 ACH50	3 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 16, 8.6 HSPF	SEER 16, 8.6 HSPF	SEER 16, 8.6 HSPF	SEER 18, 9.3 HSPF	SEER 16, 8.6 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	29.5%	29.6%	30.1%	30.3%	29.9%
	Ann. Energy Costs ($/yr)	2,600	1,835	1,837	1,839	1,864	1,865
	Ann. Energy Costs Savings (%)	0.0%	29.4%	29.3%	29.3%	28.3%	28.3%
	Source Energy Use (MMBtu/yr)	258.7	174.	173.7	172.4	172.	172.9

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

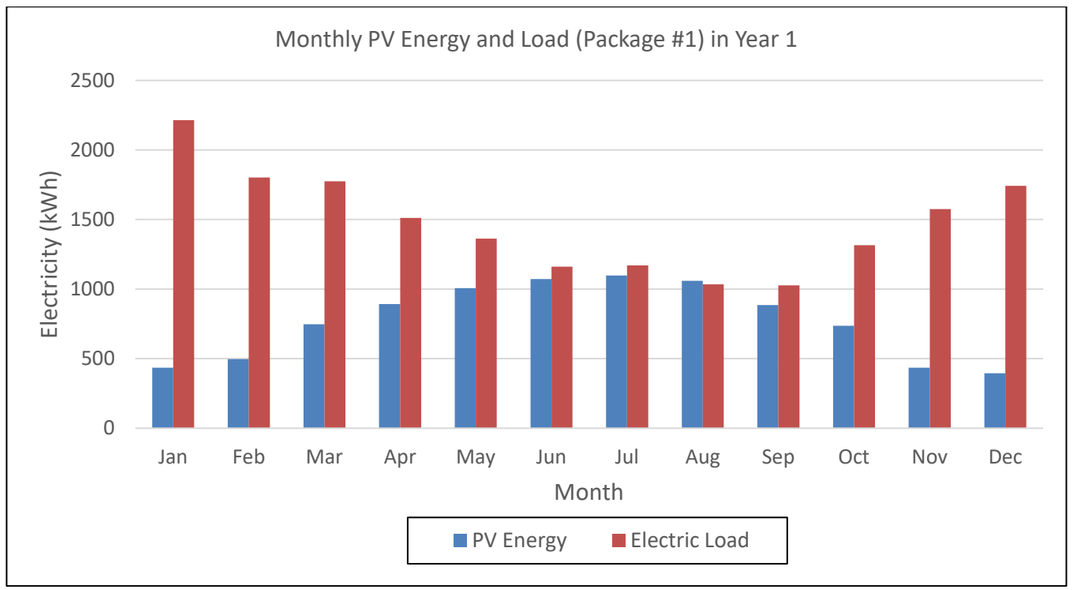
Rooftop Solar

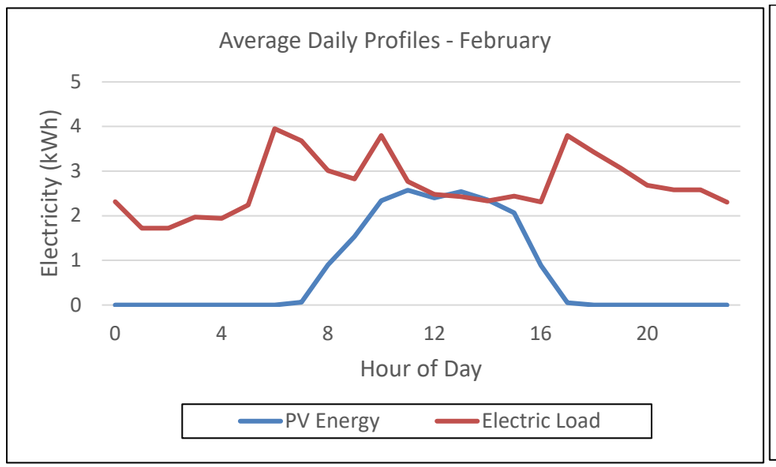
- Total PV generation (year 1): **9,258 kWh (1,424 kWh/kWdc)**
- Annual building electric load: **17,689 kWh**
- Total fraction of electric load met (year 1): **52.3%**
- Direct fraction of electric load met (year 1): **31.8%**
- Electricity cost without PV (year 1): $**1,698**
- Utility cost savings (w/ net metering) (year 1): **$889**
- Utility cost savings (w/o net metering) (year 1): **$540**
- System size: **6.5 kWdc**

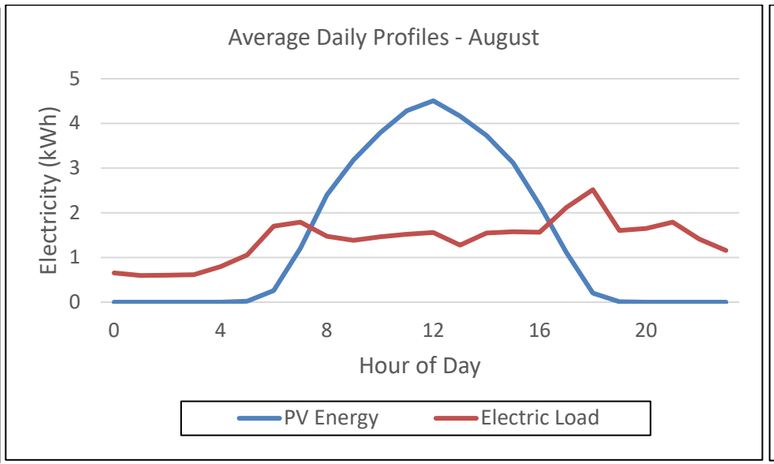
Annualized cost savings (w/ net metering): **$122**
Annualized cost savings (w/o net metering): **-$227**

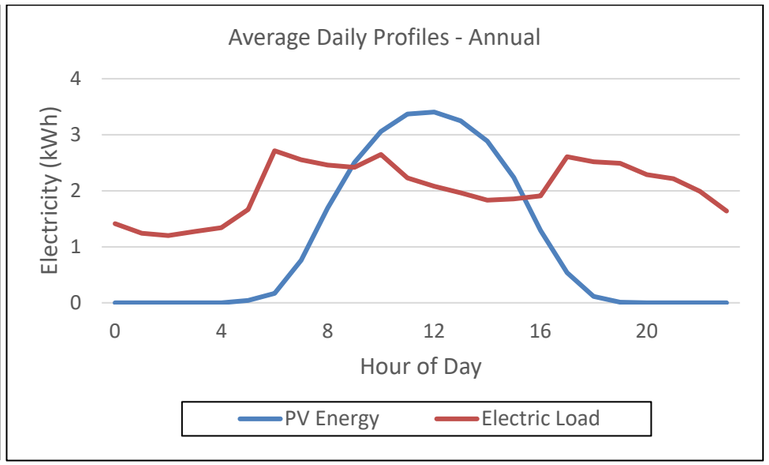
Solar Hot Water

- Estimated annual site energy savings: **16.2%**
- Utility cost savings: **$297/yr**
- Annualized cost savings: **-$284/yr**









5.23 Climate Zone 5B – Dulce, NM (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Natural Gas Rate: $1.67/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.161
1000+	$ 0.158

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R10 Exterior XPS
	Windows	U = 0.29, SHGC = 0.31	U = 0.29, SHGC = 0.31	U = 0.29, SHGC = 0.31	U = 0.19, SHGC = 0.27	U = 0.26, SHGC = 0.31	U = 0.29, SHGC = 0.26
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 14	SEER 14	SEER 14	SEER 14	SEER 14
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 80% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	12.4%	15.4%	12.4%	13.2%	12.4%
	Ann. Energy Costs ($/yr)	2,235	2,070	2,089	2,103	2,119	2,131
	Ann. Energy Costs Savings (%)	0.0%	7.4%	6.5%	5.9%	5.2%	4.6%
	Source Energy Use (MMBtu/yr)	168.4	152.7	149.2	152.8	151.7	152.9

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

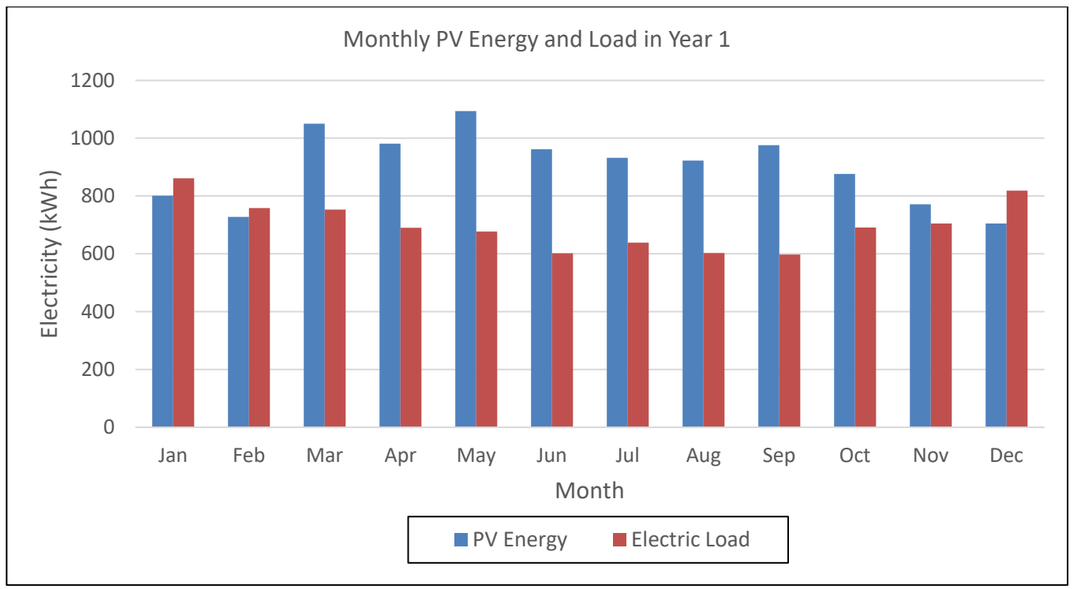
Rooftop Solar

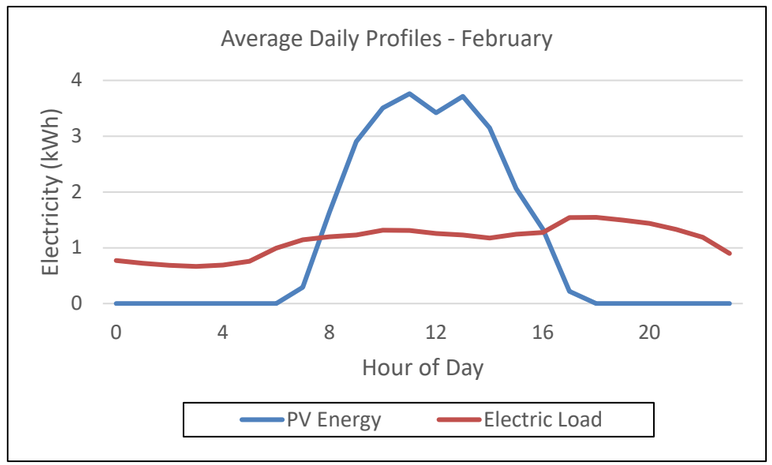
- Total PV generation (year 1): **10,799 kWh (1,661 kWh/kWdc)**
- Annual building electric load: **8,396 kWh**
- Total fraction of electric load met (year 1): **128.6%**
- Direct fraction of electric load met (year 1): **45.1%**
- Electricity cost without PV (year 1): $**1,418**
- Utility cost savings (w/ net metering) (year 1): **$1,820**
- Utility cost savings (w/o net metering) (year 1): **$793**
- System size: **6.5 kWdc**

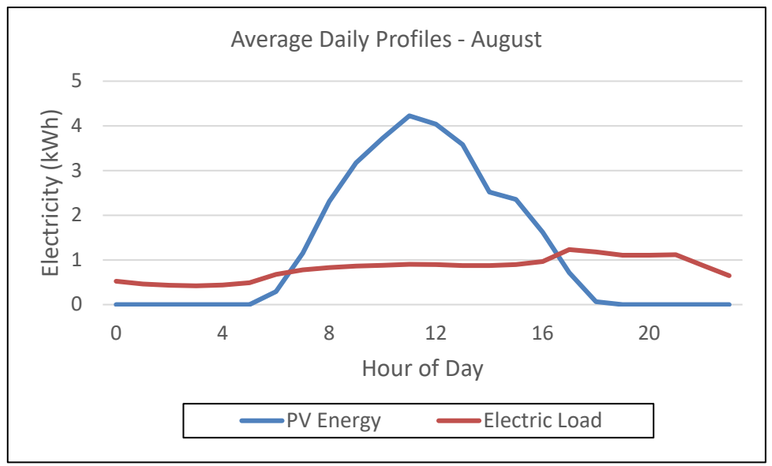
Annualized cost savings (w/ net metering): **$1,053**
Annualized cost savings (w/o net metering): **$26**

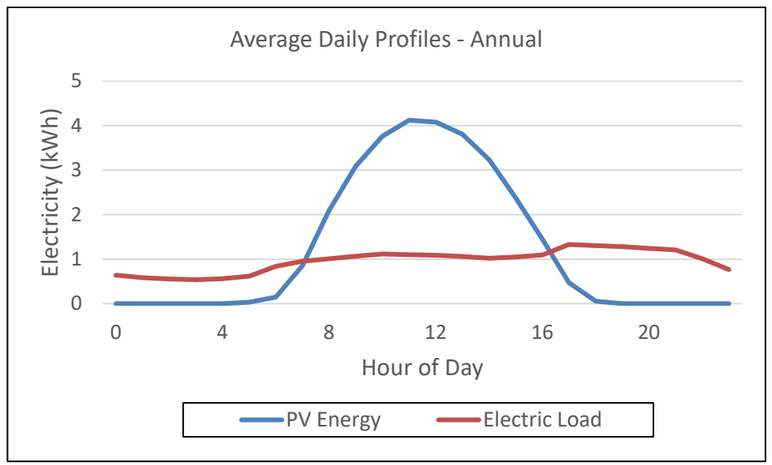
Solar Hot Water

- Estimated annual site energy savings: **19.4%**
- Utility cost savings: **$135/yr**
- Annualized cost savings: **-$447/yr**









5.24 Climate Zone 5B – Dulce, NM (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 70°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.172
500–1000	$ 0.161
1000+	$ 0.158

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	Double-Sided, Foil
	Slab	4ft R10 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.29, SHGC = 0.31	U = 0.29, SHGC = 0.31	U = 0.29, SHGC = 0.31	U = 0.26, SHGC = 0.31	U = 0.17, SHGC = 0.27	U = 0.26, SHGC = 0.31
	Air Leakage	3 ACH50	1 ACH50	2 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 18, 9.3 HSPF	SEER 18, 9.3 HSPF	SEER 19, 9.5 HSPF	SEER 19, 9.5 HSPF	SEER 19, 9.5 HSPF
	Central Air Conditioner	SEER 14	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	41.2%	41.0%	43.3%	43.4%	43.3%
	Ann. Energy Costs ($/yr)	4,298	2,981	2,999	3,020	3,046	3,053
	Ann. Energy Costs Savings (%)	0.0%	30.6%	30.2%	29.7%	29.1%	29.0%
	Source Energy Use (MMBtu/yr)	248.2	137.6	138.	132.4	132.1	132.3

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

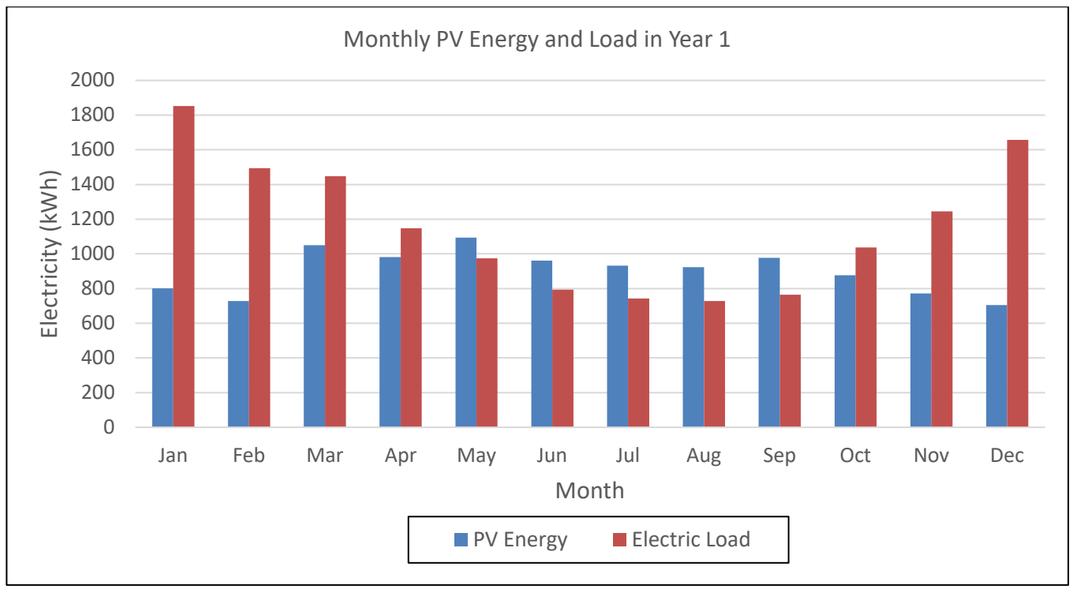
Rooftop Solar

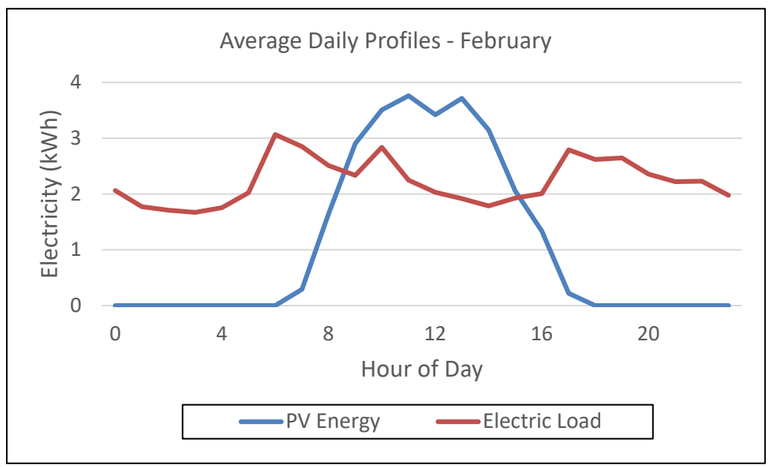
- Total PV generation (year 1): **10,799 kWh (1,661 kWh/kWdc)**
- Annual building electric load: **13,882 kWh**
- Total fraction of electric load met (year 1): **77.8%**
- Direct fraction of electric load met (year 1): **37.3%**
- Electricity cost without PV (year 1): $**2,212**
- Utility cost savings (w/ net metering) (year 1): **$1,696**
- Utility cost savings (w/o net metering) (year 1): **$668**
- System size: **6.5 kWdc**

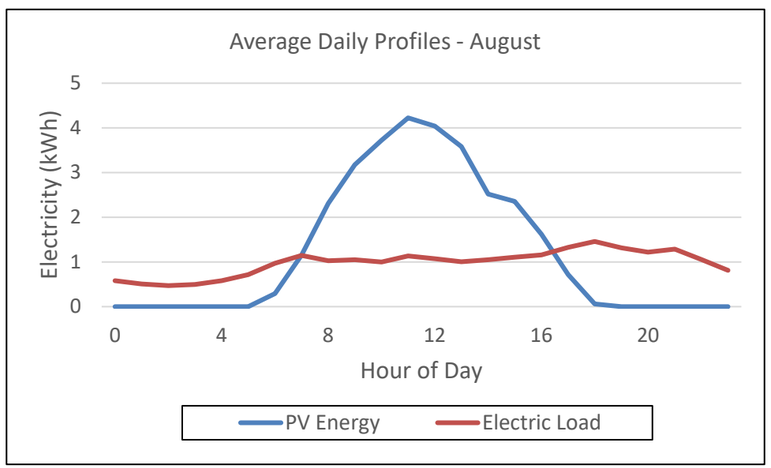
Annualized cost savings (w/ net metering): **$929**
Annualized cost savings (w/o net metering): **-$99**

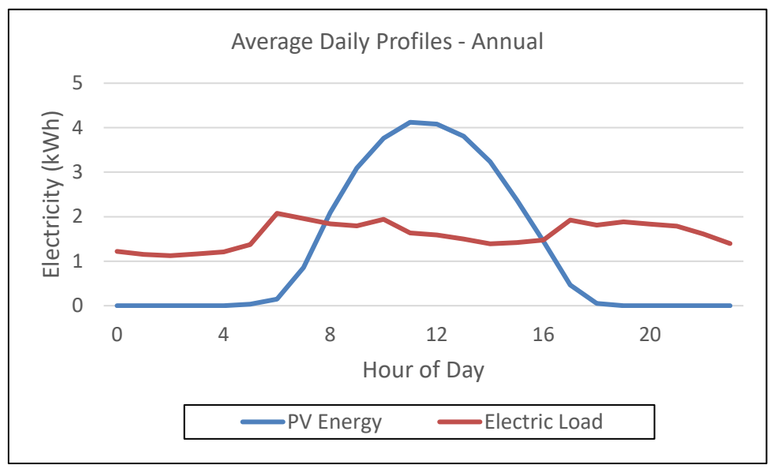
Solar Hot Water

- Estimated annual site energy savings: **10.2%**
- Utility cost savings: **$256/yr**
- Annualized cost savings: **-$325/yr**









5.25 Climate Zone 6A – Eagle Butte, SD (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Electricity Rate: $0.1106/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.30, SHGC = 0.46
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92	Electric Tank, UEF=0.92
	Air Source Heat Pump	None	SEER 15, 8.5 HSPF	SEER 15, 8.5 HSPF	SEER 22, 10 HSPF	SEER 19, 9.5 HSPF	SEER 18, 9.3 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	37.5%	37.3%	39.5%	38.3%	37.7%
	Ann. Energy Costs ($/yr)	4,560	2,977	2,984	2,994	3,044	3,049
	Ann. Energy Costs Savings (%)	0.0%	34.7%	34.6%	34.3%	33.3%	33.1%
	Source Energy Use (MMBtu/yr)	393.9	246.3	247.0	238.1	243.1	245.4

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

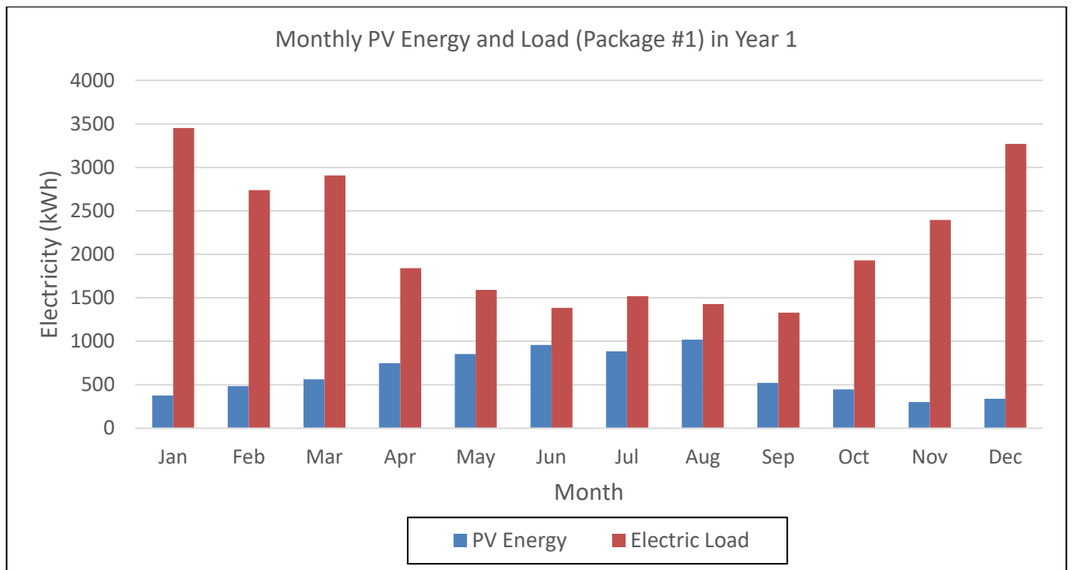
Rooftop Solar

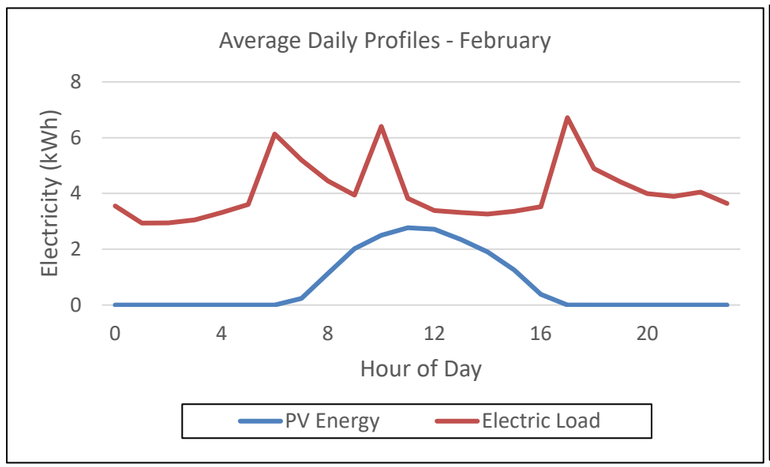
- Total PV generation (year 1): **7,497 kWh (1,153 kWh/kWdc)**
- Annual building electric load: **25,782 kWh**
- Total fraction of electric load met (year 1): **29.1%**
- Direct fraction of electric load met (year 1): **21.8%**
- Electricity cost without PV (year 1): $**2,852**
- Utility cost savings (w/ net metering) (year 1): **$829**
- Utility cost savings (w/o net metering) (year 1): **$621**
- System size: **6.5 kWdc**

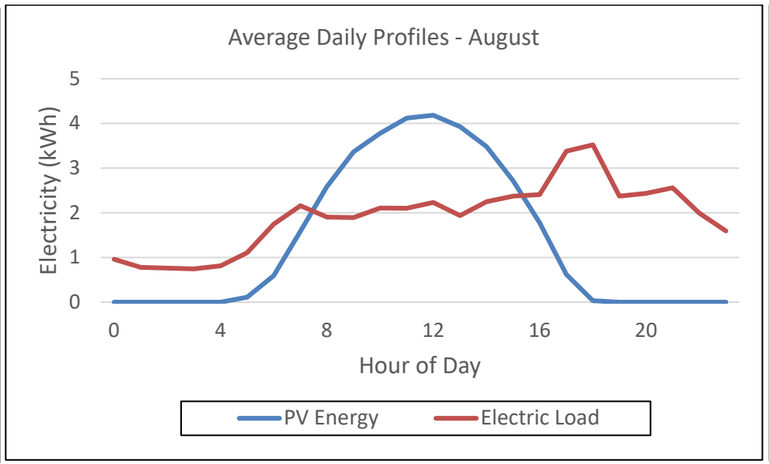
Annualized cost savings (w/ net metering): **$62**
Annualized cost savings (w/o net metering): **-$146**

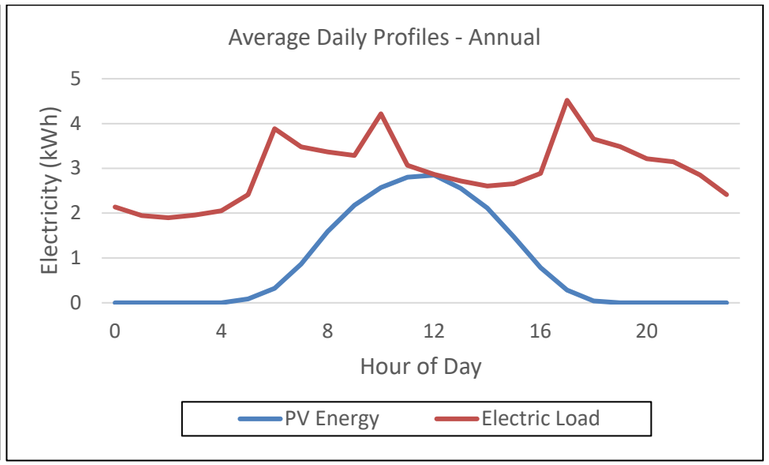
Solar Hot Water

- Estimated annual site energy savings: **9.7%**
- Utility cost savings: **$278/yr**
- Annualized cost savings: **-$304/yr**









5.26 Climate Zone 6A – Eagle Butte, SD (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Propane Rate: $2.17/gal
Electricity Rate: $0.1106/kWh

IHS Area: Great Plains

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.29, SHGC = 0.56
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 13
	Furnace	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 94% AFUE	Propane, 96% AFUE	Propane, 96% AFUE	Propane, 94% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	26.7%	26.2%	29.4%	29.0%	25.8%
	Ann. Energy Costs ($/yr)	4,412	3,650	3,714	3,735	3,745	3,751
	Ann. Energy Costs Savings (%)	0.0%	17.3%	15.8%	15.3%	15.1%	15.0%
	Source Energy Use (MMBtu/yr)	247.9	200.3	201.4	193.0	193.8	202.1

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

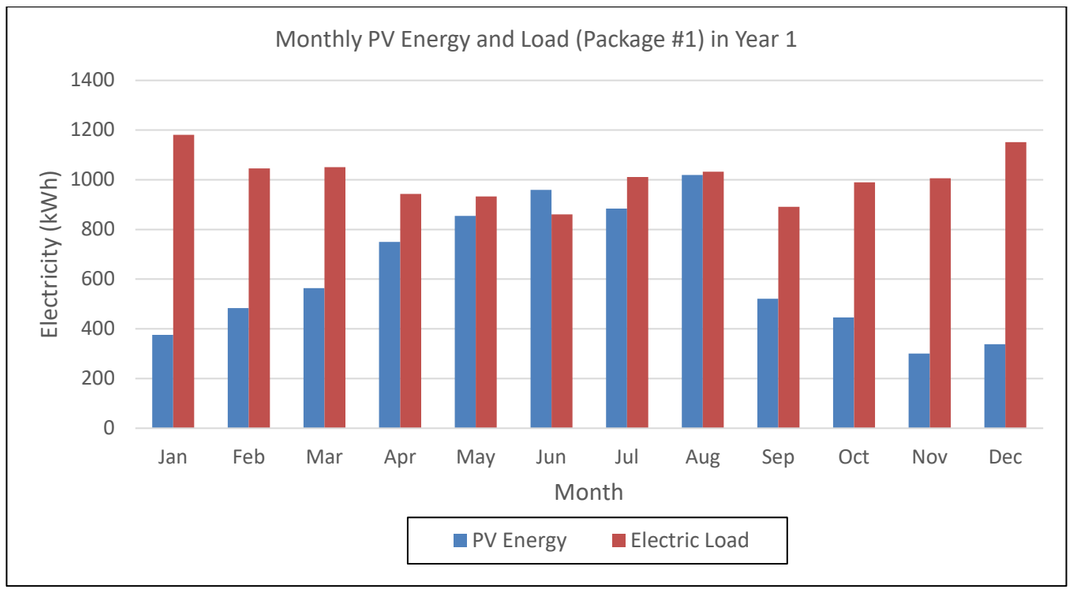
Rooftop Solar

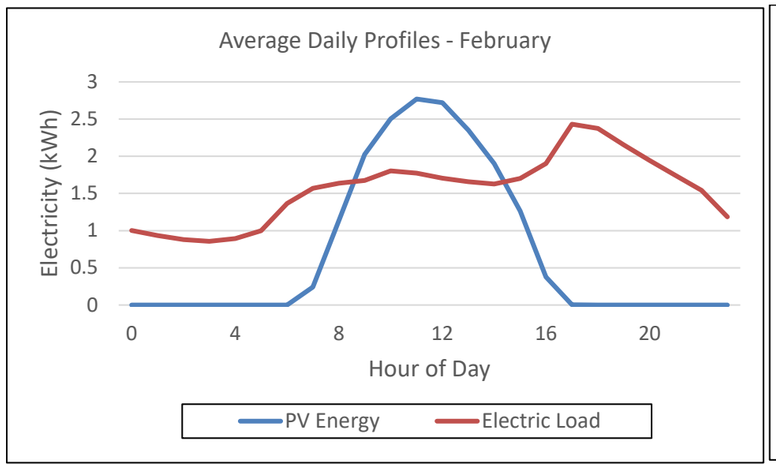
- Total PV generation (year 1): **7,497 kWh (1,153 kWh/kWdc)**
- Annual building electric load: **12,099 kWh**
- Total fraction of electric load met (year 1): **62.0%**
- Direct fraction of electric load met (year 1): **35.1%**
- Electricity cost without PV (year 1): **$1,338**
- Utility cost savings (w/ net metering) (year 1): **$829**
- Utility cost savings (w/o net metering) (year 1): **$469**
- System size: **6.5 kWdc**

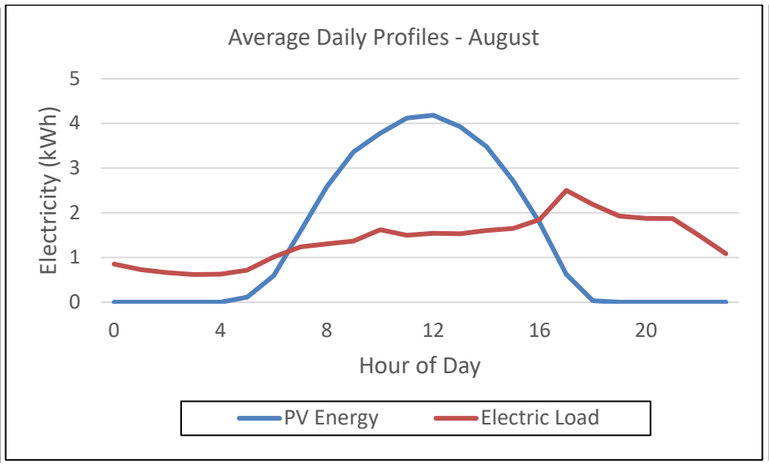
Annualized cost savings (w/ net metering): **$62**
Annualized cost savings (w/o net metering): **-$298**

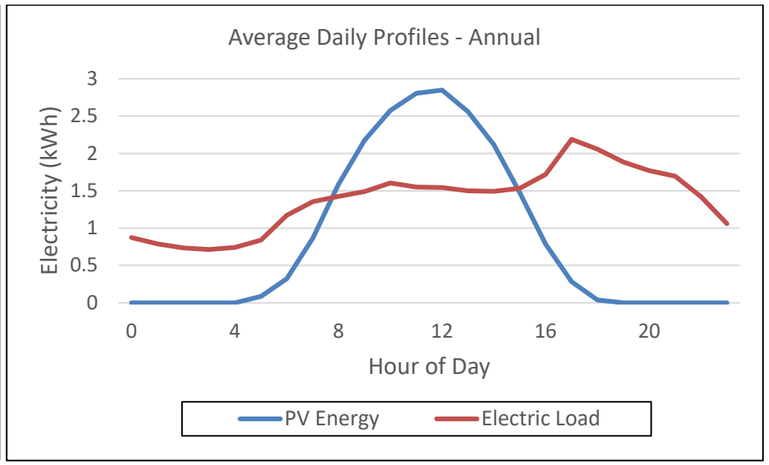
Solar Hot Water

- Estimated annual site energy savings: **10.4%**
- Utility cost savings: **$301/yr**
- Annualized cost savings: **-$281/yr**









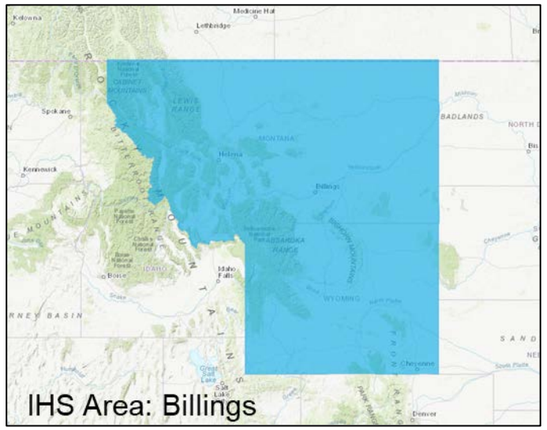
5.27 Climate Zone 6B – Ft. Washakie, WY (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Natural Gas Rate: $0.902/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.128
500–1000	$ 0.119
1000–1500	$ 0.116
1500+	$ 0.115



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-15 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.30, SHGC = 0.46	U = 0.30, SHGC = 0.46
	Air Leakage	3 ACH50	2 ACH50	1 ACH50	1 ACH50	2 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 16 (2 Stage)	SEER 13	SEER 13
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	14.6%	15.2%	16.4%	14.8%	14.4%
	Ann. Energy Costs ($/yr)	2,379	2,168	2,170	2,174	2,191	2,222
	Ann. Energy Costs Savings (%)	0.0%	8.9%	8.8%	8.6%	7.9%	6.6%
	Source Energy Use (MMBtu/yr)	214.8	191.2	190.3	186.1	190.9	191.7

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

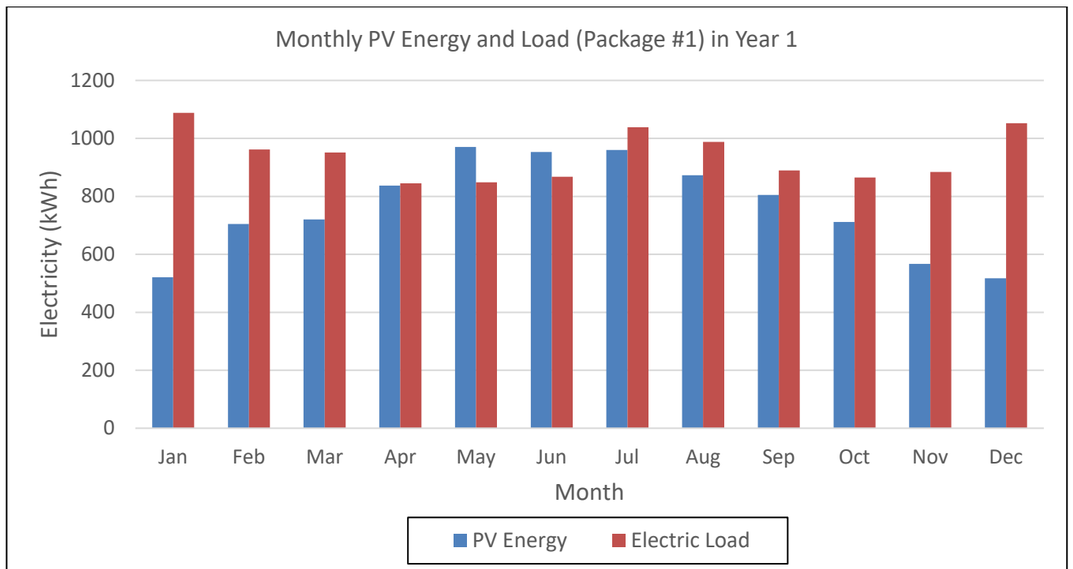
Rooftop Solar

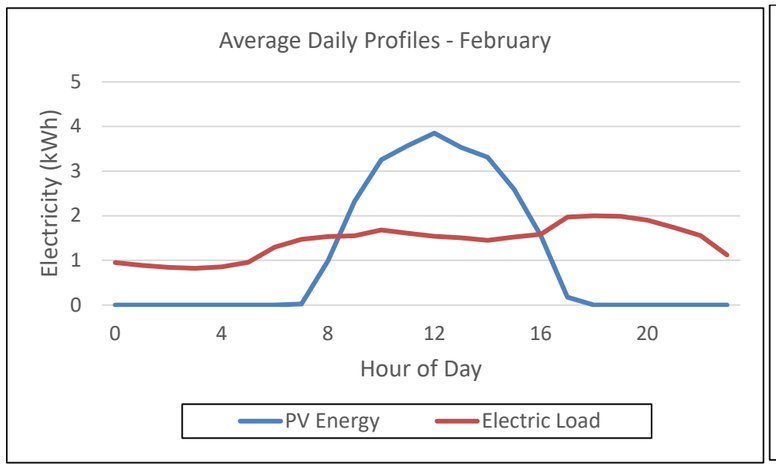
- Total PV generation (year 1): **9,139 kWh (1,406 kWh/kWdc)**
- Annual building electric load: **11,280 kWh**
- Total fraction of electric load met (year 1): **81.0%**
- Direct fraction of electric load met (year 1): **40.7%**
- Electricity cost without PV (year 1): $**1,396**
- Utility cost savings (w/ net metering) (year 1): **$1,129**
- Utility cost savings (w/o net metering) (year 1): **$547**
- System size: **6.5 kWdc**

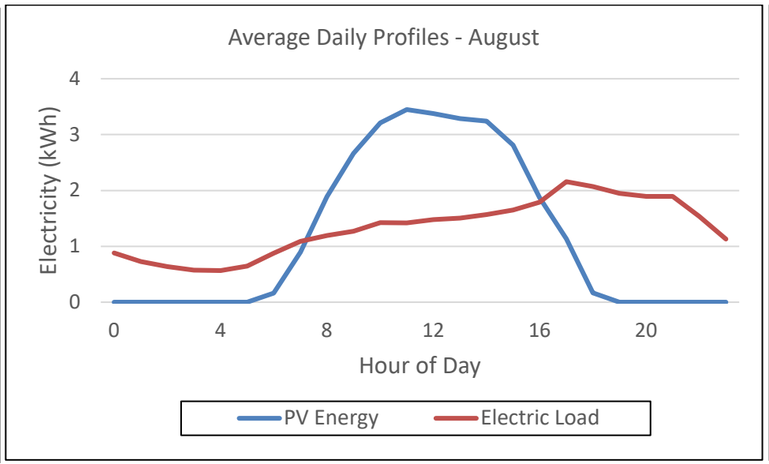
Annualized cost savings (w/ net metering): **$362**
Annualized cost savings (w/o net metering): **-$220**

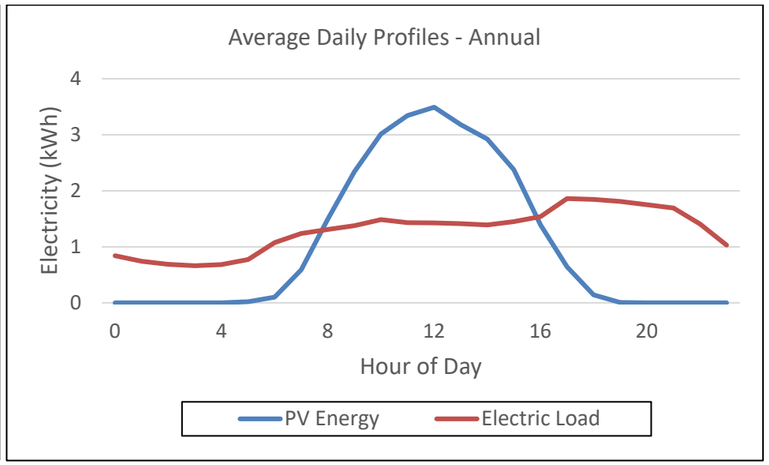
Solar Hot Water

- Estimated annual site energy savings: **13.7%**
- Utility cost savings: **$123/yr**
- Annualized cost savings: **-$459/yr**









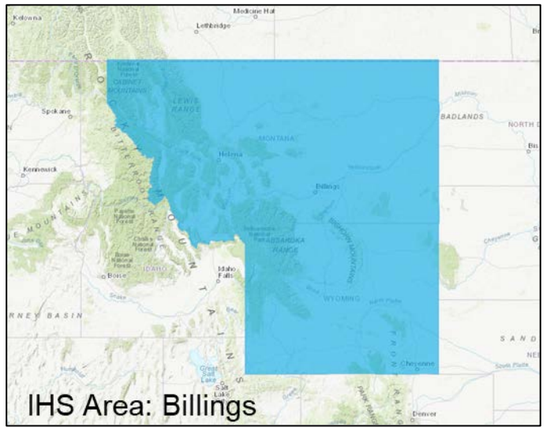
5.28 Climate Zone 6B – Ft. Washakie, WY (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Propane Rate: $2.29/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.128
500–1000	$ 0.119
1000–1500	$ 0.116
1500+	$ 0.115



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-10 XPS	R-10 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.29, SHGC = 0.56
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 18	SEER 16 (2 Stage)
	Furnace	Propane, 80% AFUE	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 94% AFUE	Propane, 80% AFUE	Propane, 96% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	22.5%	24.7%	25.8%	23.5%	27.9%
	Ann. Energy Costs ($/yr)	3,930	3,337	3,383	3,418	3,418	3,440
	Ann. Energy Costs Savings (%)	0.0%	15.1%	13.9%	13.0%	13.0%	12.5%
	Source Energy Use (MMBtu/yr)	213.2	181.8	179.0	177.5	177.6	172.2

Code Minimum
Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

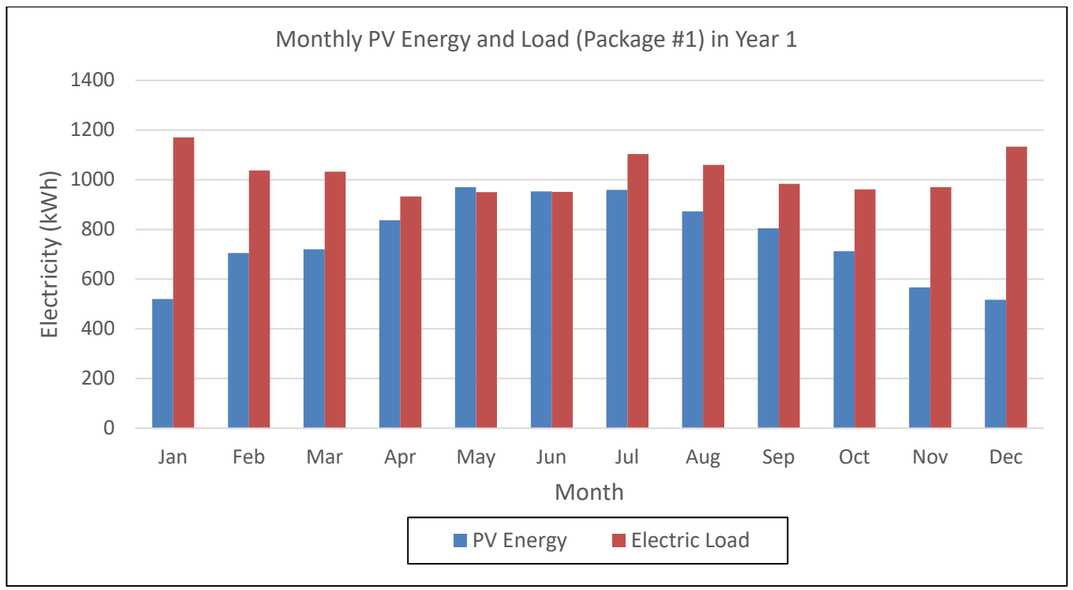
Rooftop Solar

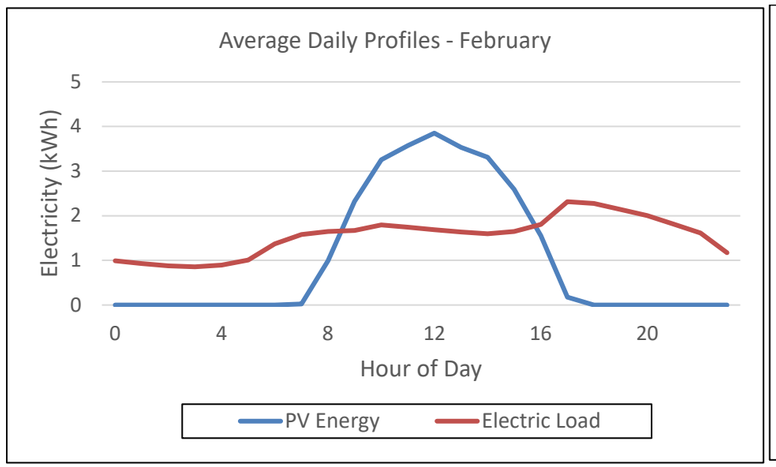
- Total PV generation (year 1): **9,139 kWh (1,406 kWh/kWdc)**
- Annual building electric load: **12,289 kWh**
- Total fraction of electric load met (year 1): **74.4%**
- Direct fraction of electric load met (year 1): **40.0%**
- Electricity cost without PV (year 1): $**1,515**
- Utility cost savings (w/ net metering) (year 1): **$1,124**
- Utility cost savings (w/o net metering) (year 1): **$583**
- System size: **6.5 kWdc**

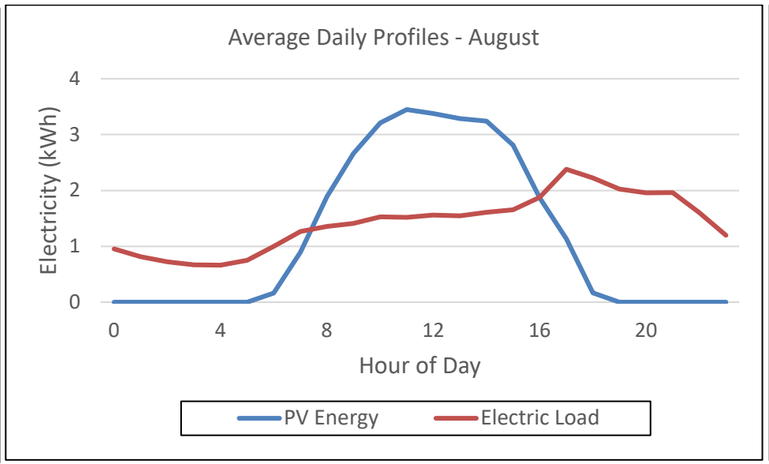
Annualized cost savings (w/ net metering): **$357**
Annualized cost savings (w/o net metering): **-$184**

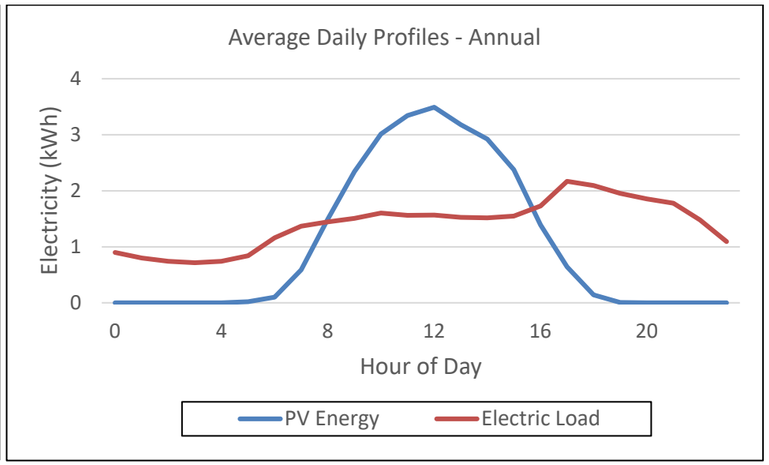
Solar Hot Water

- Estimated annual site energy savings: **15.3%**
- Utility cost savings: **$394/yr**
- Annualized cost savings: **-$188/yr**









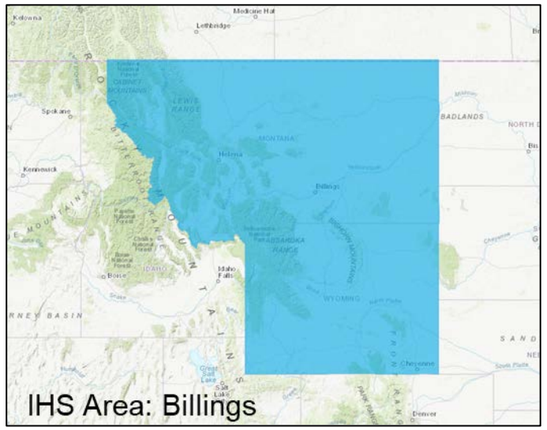
5.29 Climate Zone 6B – Crow Agency, MT (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Natural Gas Rate: $0.848/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.134
500–1000	$ 0.128
1000–1500	$ 0.127
1500+	$ 0.126



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-10 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.30, SHGC = 0.46	U = 0.30, SHGC = 0.46	U = 0.27, SHGC = 0.46	U = 0.30, SHGC = 0.46	U = 0.30, SHGC = 0.46
	Air Leakage	3 ACH50	3 ACH50	3 ACH50	2 ACH50	3 ACH50	2 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 16 (2 Stage)	SEER 13
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	11.5%	12.5%	12.1%	13.5%	13.2%
	Ann. Energy Costs ($/yr)	2,350	2,143	2,147	2,152	2,155	2,166
	Ann. Energy Costs Savings (%)	0.0%	8.8%	8.7%	8.4%	8.3%	7.8%
	Source Energy Use (MMBtu/yr)	211.5	192.7	191.1	191.8	187.4	190.5

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

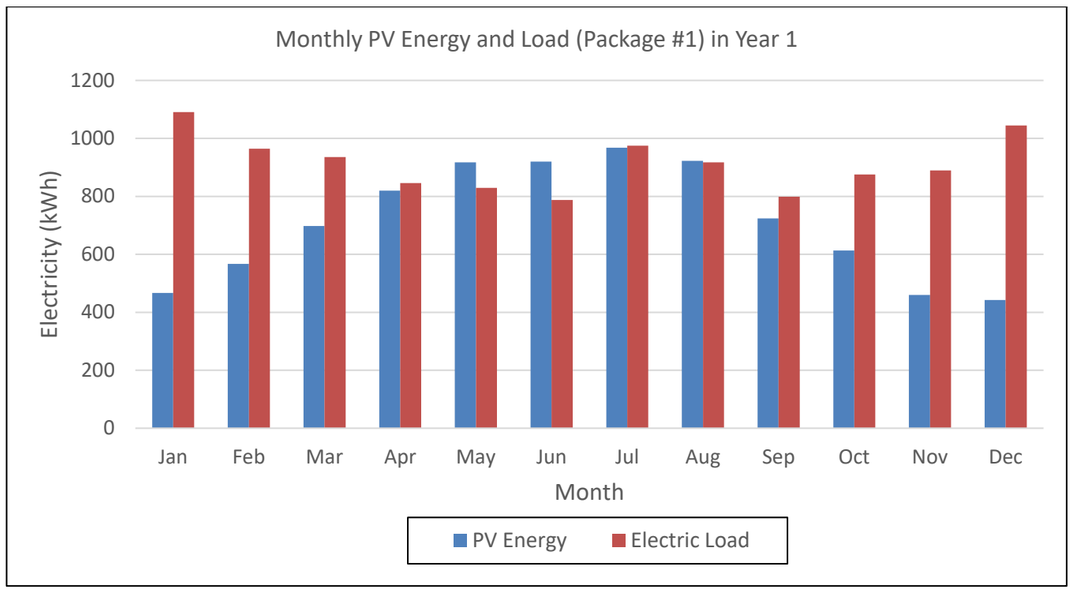
Rooftop Solar

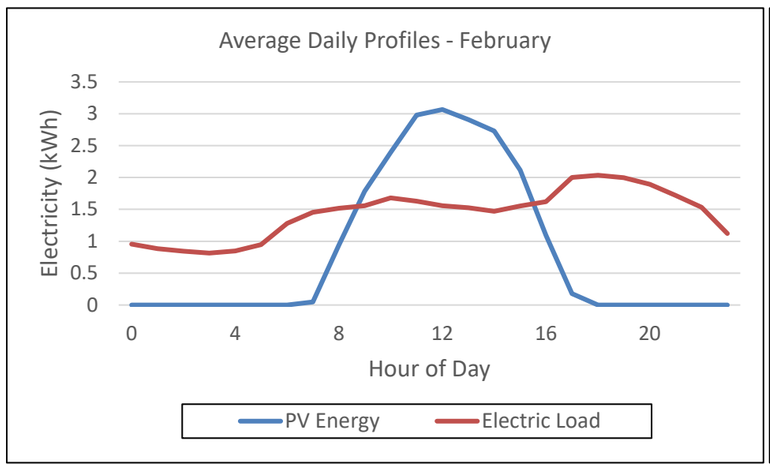
- Total PV generation (year 1): **8,515 kWh (1,310 kWh/kWdc)**
- Annual building electric load: **10,954 kWh**
- Total fraction of electric load met (year 1): **77.7%**
- Direct fraction of electric load met (year 1): **40.6%**
- Electricity cost without PV (year 1): $**1,438**
- Utility cost savings (w/ net metering) (year 1): **$1,116**
- Utility cost savings (w/o net metering) (year 1): **$571**
- System size: **6.5 kWdc**

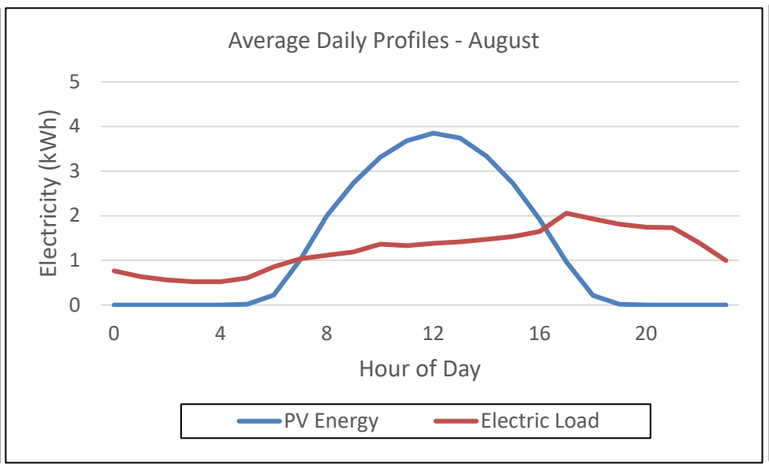
Annualized cost savings (w/ net metering): **$349**
Annualized cost savings (w/o net metering): **-$196**

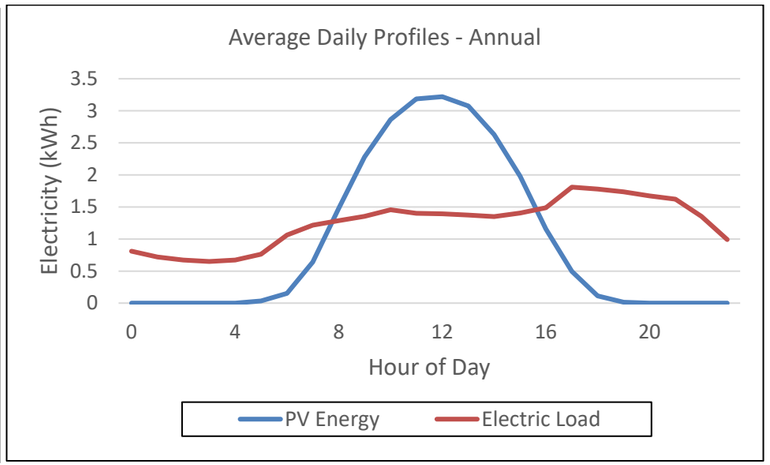
Solar Hot Water

- Estimated annual site energy savings: **12.5%**
- Utility cost savings: **$105/yr**
- Annualized cost savings: **-$477/yr**









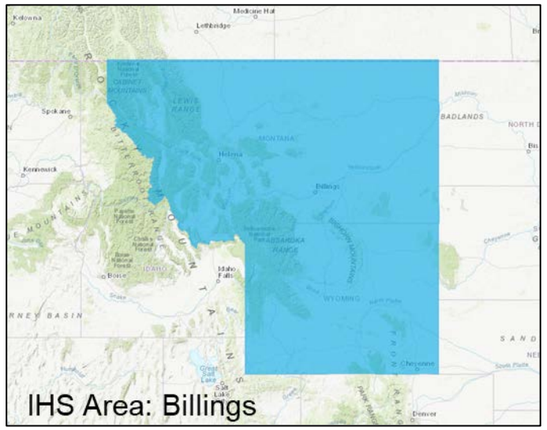
5.30 Climate Zone 6B – Crow Agency, MT (Propane Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Propane
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Propane Rate: $2.55/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.134
500–1000	$ 0.128
1000–1500	$ 0.127
1500+	$ 0.126



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.18, SHGC = 0.40	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Propane Tank, UEF=0.62	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82	Propane Tankless, UEF=0.82
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 13	SEER 16	SEER 16
	Furnace	Propane, 80% AFUE	Propane, 90% AFUE	Propane, 94% AFUE	Propane, 94% AFUE	Propane, 96% AFUE	Propane, 96% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	26.3%	26.0%	25.6%	27.9%	27.4%
	Ann. Energy Costs ($/yr)	4,229	3,605	3,659	3,698	3,698	3,707
	Ann. Energy Costs Savings (%)	0.0%	14.8%	13.5%	12.5%	12.5%	12.3%
	Source Energy Use (MMBtu/yr)	209.9	173.3	174.2	174.3	169.9	170.5

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

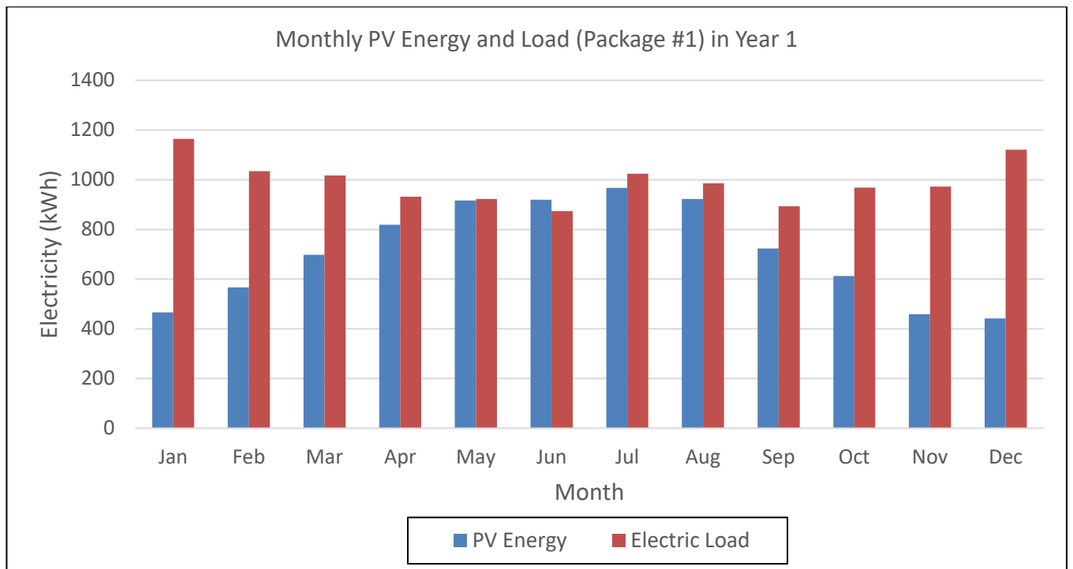
Rooftop Solar

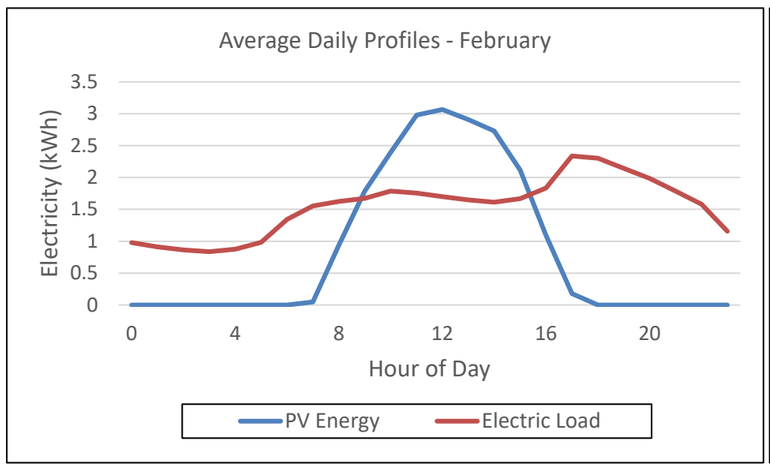
- Total PV generation (year 1): **8,515 kWh (1,310 kWh/kWdc)**
- Annual building electric load: **11,911 kWh**
- Total fraction of electric load met (year 1): **71.5%**
- Direct fraction of electric load met (year 1): **39.7%**
- Electricity cost without PV (year 1): $**1,560**
- Utility cost savings (w/ net metering) (year 1): **$1,113**
- Utility cost savings (w/o net metering) (year 1): **$606**
- System size: **6.5 kWdc**

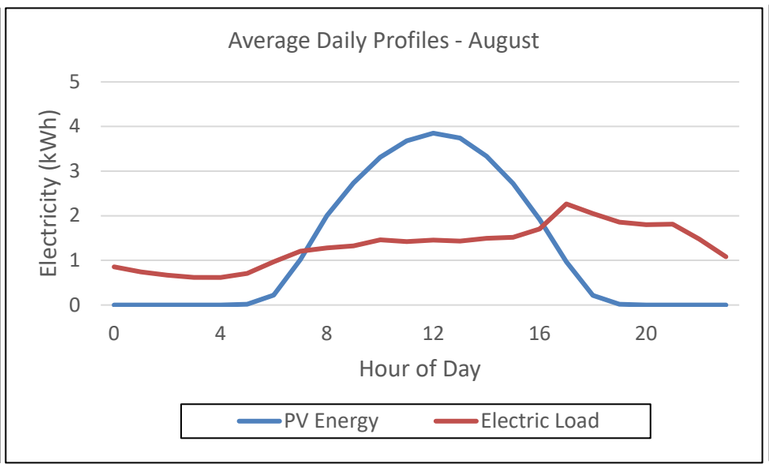
Annualized cost savings (w/ net metering): **$346**
Annualized cost savings (w/o net metering): **-$161**

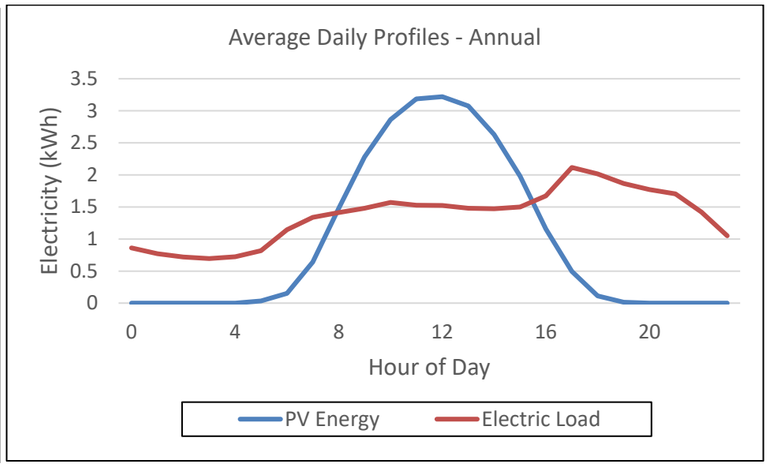
Solar Hot Water

- Estimated annual site energy savings: **15.1%**
- Utility cost savings: **$410/yr**
- Annualized cost savings: **-$172/yr**









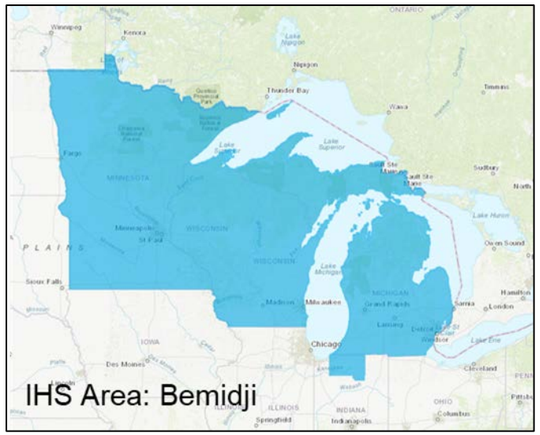
5.31 Climate Zone 7A – Bemidji, MN (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Natural Gas Rate: $1.66/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.180
500–1000	$ 0.170
1000–1500	$ 0.167
1500+	$ 0.165



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96	Gas Tankless, Cond. UEF=0.96
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 16	SEER 16	SEER 24.5
	Furnace	Gas, 80% AFUE	Gas, 98% AFUE	Gas, 98% AFUE	Gas, 95% AFUE	Gas, 98% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	31.1%	30.2%	30.6%	30.8%	31.4%
	Ann. Energy Costs ($/yr)	4,417	3,724	3,739	3,775	3,789	3,873
	Ann. Energy Costs Savings (%)	0.0%	15.7%	15.4%	14.5%	14.2%	12.3%
	Source Energy Use (MMBtu/yr)	259.2	198.8	200.8	198.2	197.8	195.9

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

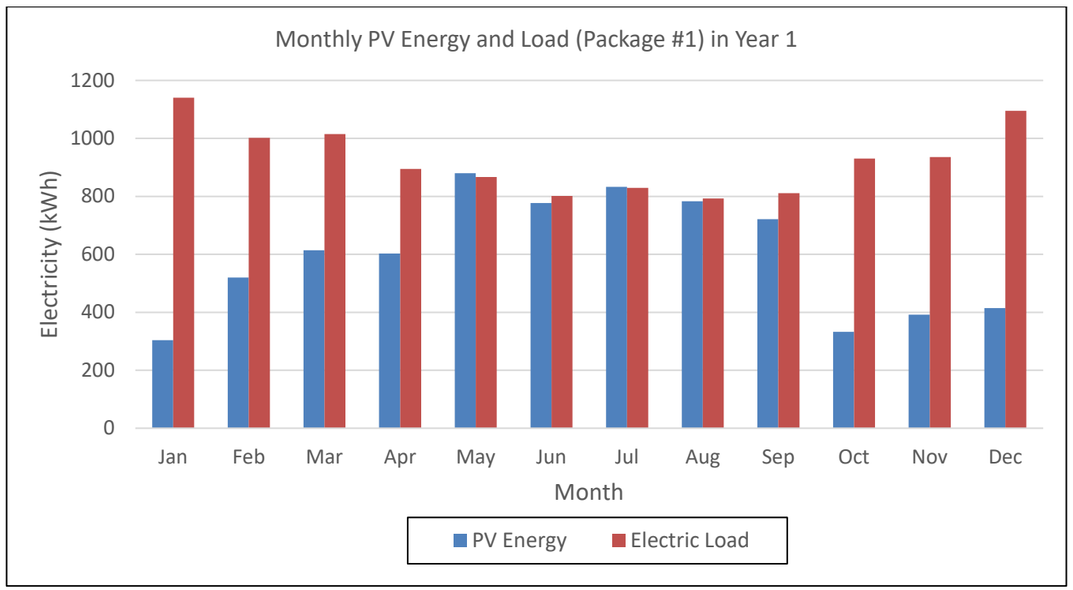
Rooftop Solar

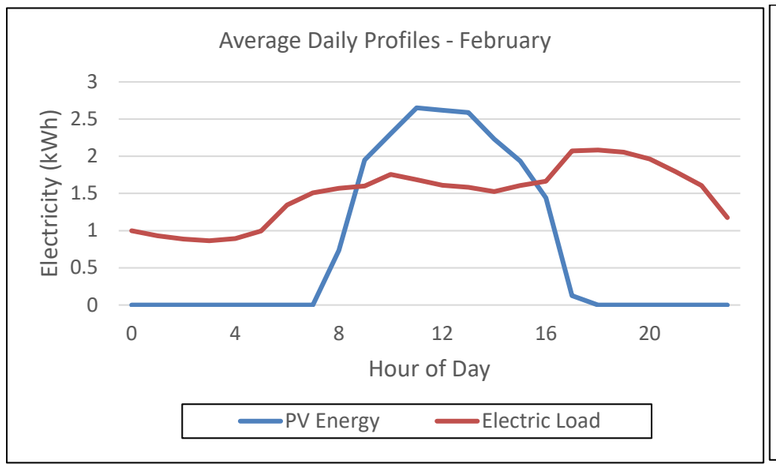
- Total PV generation (year 1): **7,174 kWh (1,104 kWh/kWdc)**
- Annual building electric load: **11,114 kWh**
- Total fraction of electric load met (year 1): **64.6%**
- Direct fraction of electric load met (year 1): **36.3%**
- Electricity cost without PV (year 1): $**1,949**
- Utility cost savings (w/ net metering) (year 1): **$1,254**
- Utility cost savings (w/o net metering) (year 1): **$688**
- System size: **6.5 kWdc**

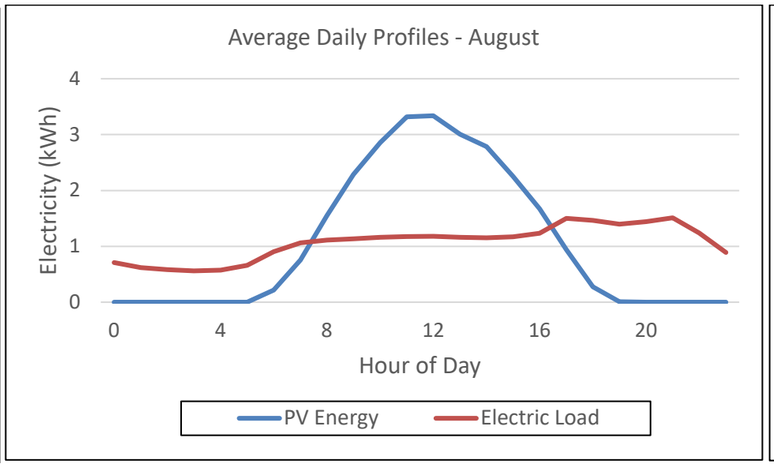
Annualized cost savings (w/ net metering): **$487**
Annualized cost savings (w/o net metering): **-$79**

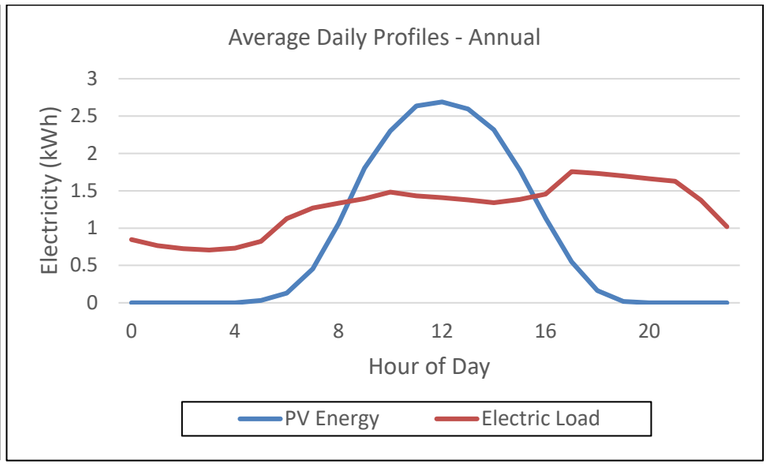
Solar Hot Water

- Estimated annual site energy savings: **9.0%**
- Utility cost savings: **$164/yr**
- Annualized cost savings: **-$417/yr**









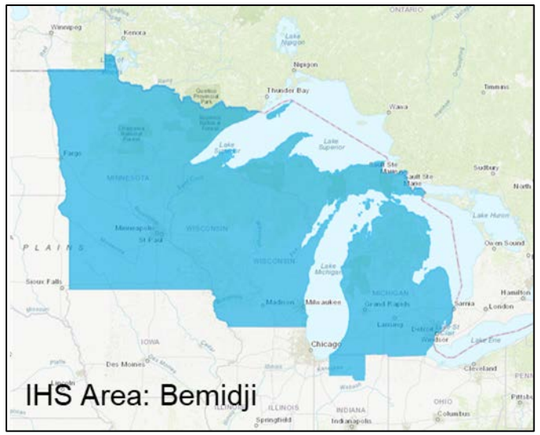
5.32 Climate Zone 7A – Bemidji, MN (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.180
500–1000	$ 0.170
1000–1500	$ 0.167
1500+	$ 0.165



Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	47.0%	46.6%	46.6%	47.2%	46.8%
	Ann. Energy Costs ($/yr)	7,277	4,662	4,681	4,681	4,696	4,710
	Ann. Energy Costs Savings (%)	0.0%	35.9%	35.7%	35.7%	35.5%	35.3%
	Source Energy Use (MMBtu/yr)	407.1	215.7	217.4	217.3	214.9	216.7

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

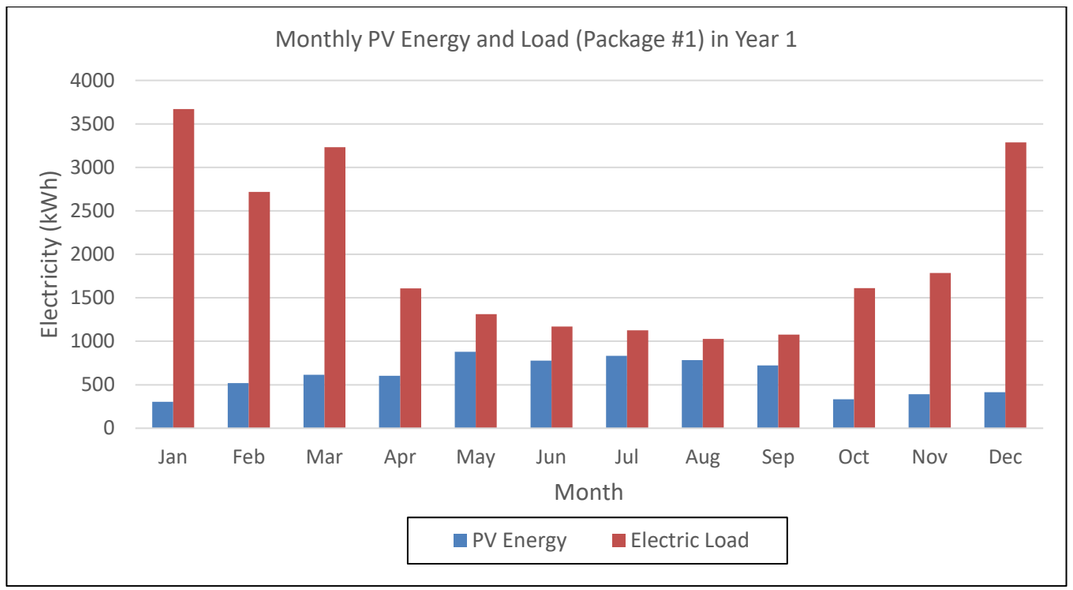
Rooftop Solar

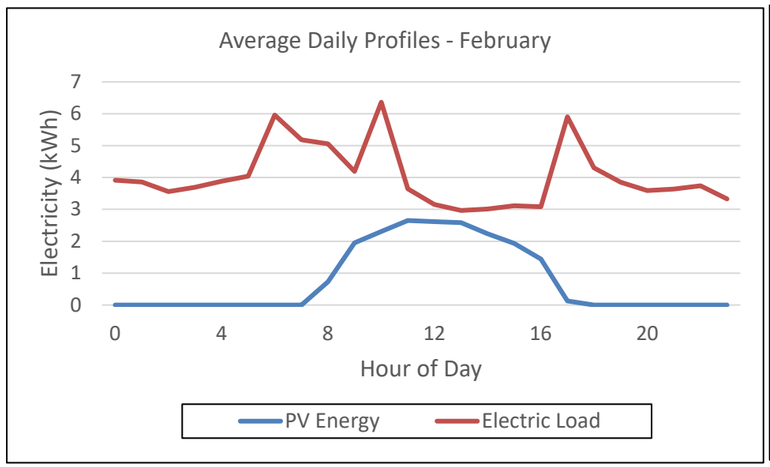
- Total PV generation (year 1): **7,174 kWh (1,104 kWh/kWdc)**
- Annual building electric load: **23,628 kWh**
- Total fraction of electric load met (year 1): **30.4%**
- Direct fraction of electric load met (year 1): **21.7%**
- Electricity cost without PV (year 1): $**4,027**
- Utility cost savings (w/ net metering) (year 1): **$1,225**
- Utility cost savings (w/o net metering) (year 1): **$856**
- System size: **6.5 kWdc**

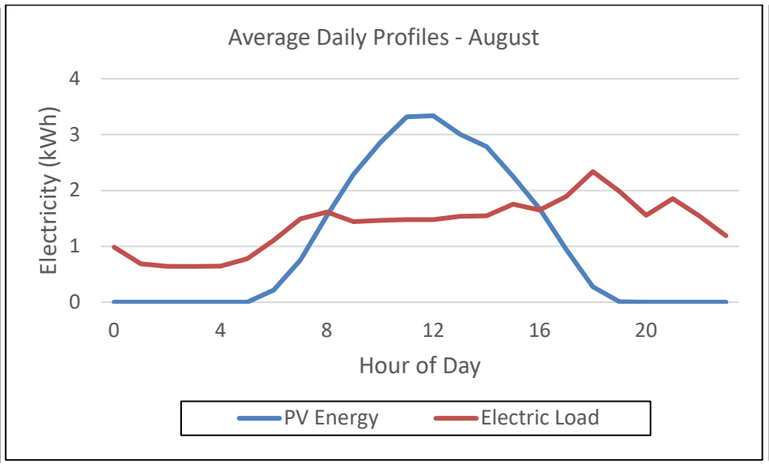
Annualized cost savings (w/ net metering): **$458**
Annualized cost savings (w/o net metering): **$89**

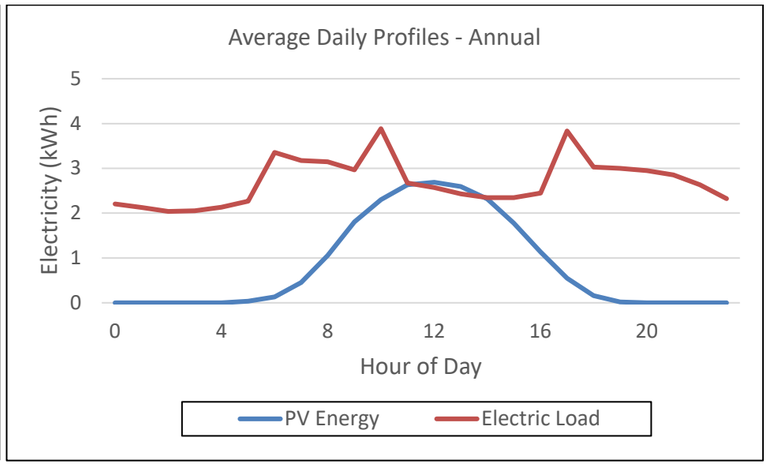
Solar Hot Water

- Estimated annual site energy savings: **7.0%**
- Utility cost savings: **$273/yr**
- Annualized cost savings: **-$309/yr**









5.33 Climate Zone 7A – Belcourt, ND (Fuel Oil Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Fuel Oil
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Fuel Oil Rate: $2.88/gal
Electricity Rate: $0.1456/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-15 Fiberglass, 2x4, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.18, SHGC = 0.40	U = 0.21, SHGC = 0.40	U = 0.21, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Fuel Oil Tank, UEF=0.62	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67
	Central Air Conditioner	SEER 13	SEER 13	SEER 13	SEER 14	SEER 13	SEER 13
	Furnace	Oil, 80% AFUE	Oil, 80% AFUE	Oil, 90% AFUE	Oil, 80% AFUE	Oil, 90% AFUE	Oil, 94% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	23.1%	27.6%	22.6%	27.2%	28.6%
	Ann. Energy Costs ($/yr)	4,511	3,872	3,895	3,897	3,908	3,974
	Ann. Energy Costs Savings (%)	0.0%	14.2%	13.7%	13.6%	13.4%	11.9%
	Source Energy Use (MMBtu/yr)	273.3	224.7	215.3	225.6	216.3	213.3

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

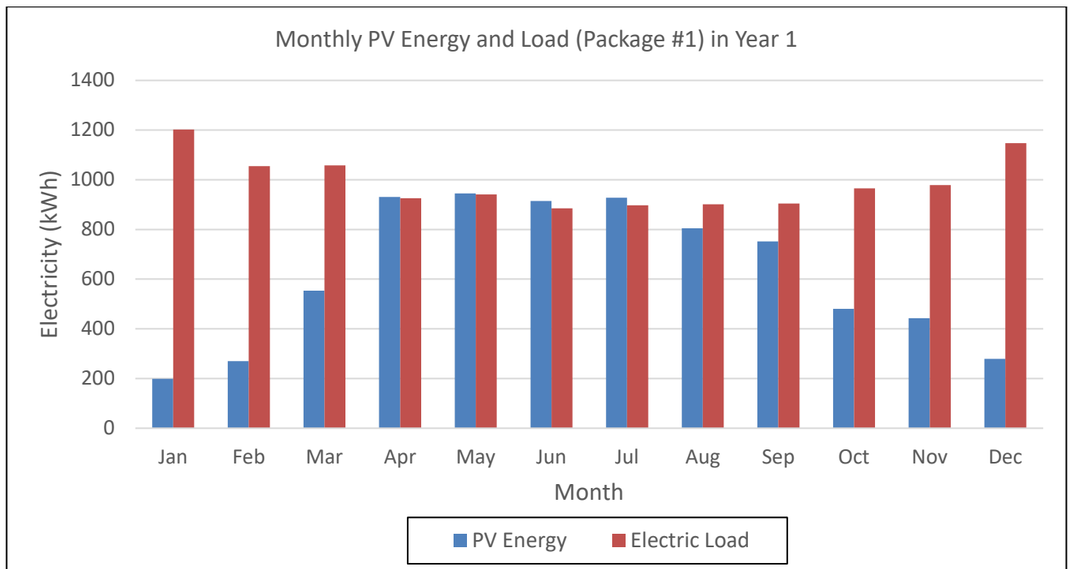
Rooftop Solar

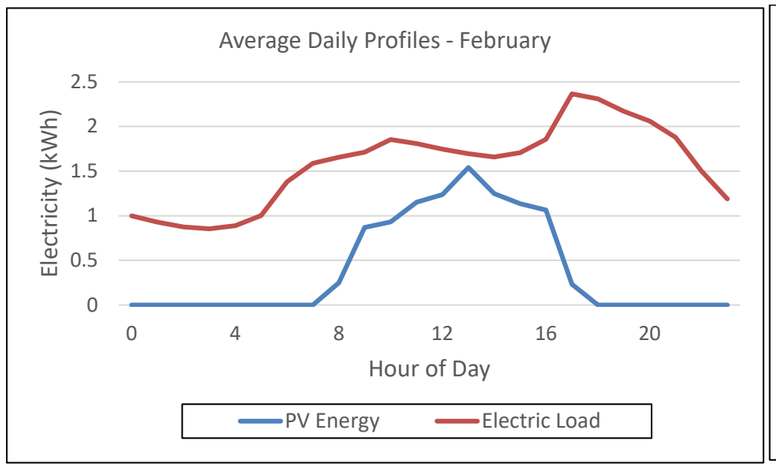
- Total PV generation (year 1): **7,499 kWh (1,154 kWh/kWdc)**
- Annual building electric load: **11,861 kWh**
- Total fraction of electric load met (year 1): **63.2%**
- Direct fraction of electric load met (year 1): **35.2%**
- Electricity cost without PV (year 1): $**1,727**
- Utility cost savings (w/ net metering) (year 1): **$1,092**
- Utility cost savings (w/o net metering) (year 1): **$608**
- System size: **6.5 kWdc**

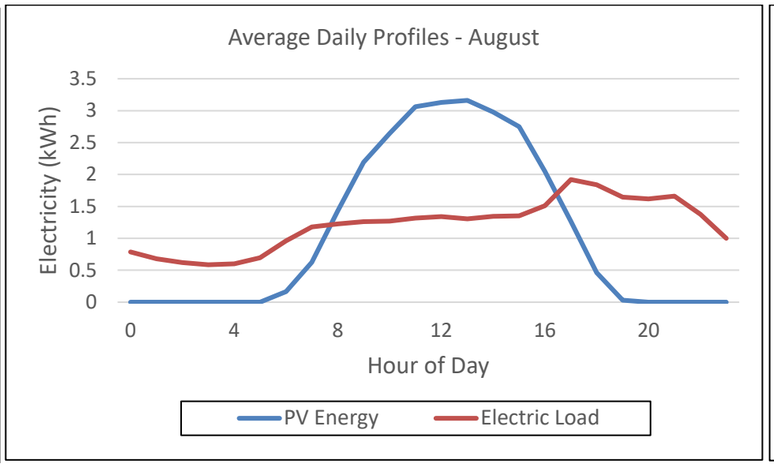
Annualized cost savings (w/ net metering): **$325**
Annualized cost savings (w/o net metering): **-$159**

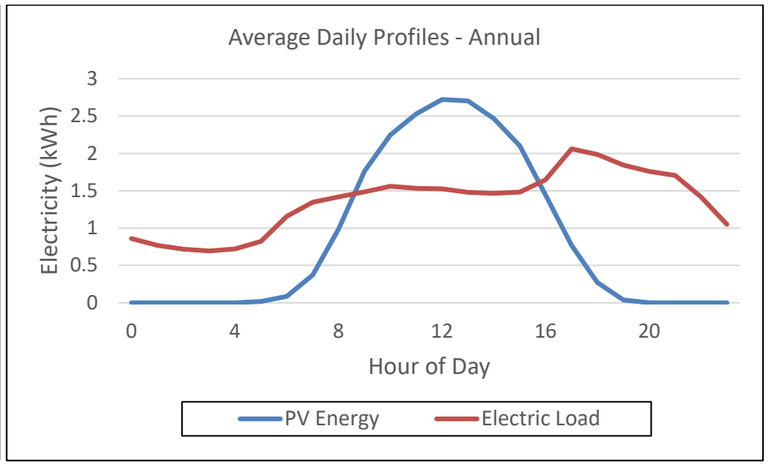
Solar Hot Water

- Estimated annual site energy savings: **8.4%**
- Utility cost savings: **$218/yr**
- Annualized cost savings: **-$364/yr**









5.34 Climate Zone 7A – Belcourt, ND (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Finished Basement
Electricity Rate: $0.1456/kWh

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-10 XPS	R-15 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Finished Basement	Whole Wall R-15 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-20 XPS	Whole Wall R-15 XPS	Whole Wall R-20 XPS
	Windows	U = 0.30, SHGC = 0.46	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.29, SHGC = 0.56	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 19, 9.5 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	46.6%	47.0%	46.7%	46.0%	45.9%
	Ann. Energy Costs ($/yr)	5,949	3,877	3,902	3,909	3,915	3,959
	Ann. Energy Costs Savings (%)	0.0%	34.8%	34.4%	34.3%	34.2%	33.4%
	Source Energy Use (MMBtu/yr)	390.3	208.4	206.9	208.0	210.8	211.2

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

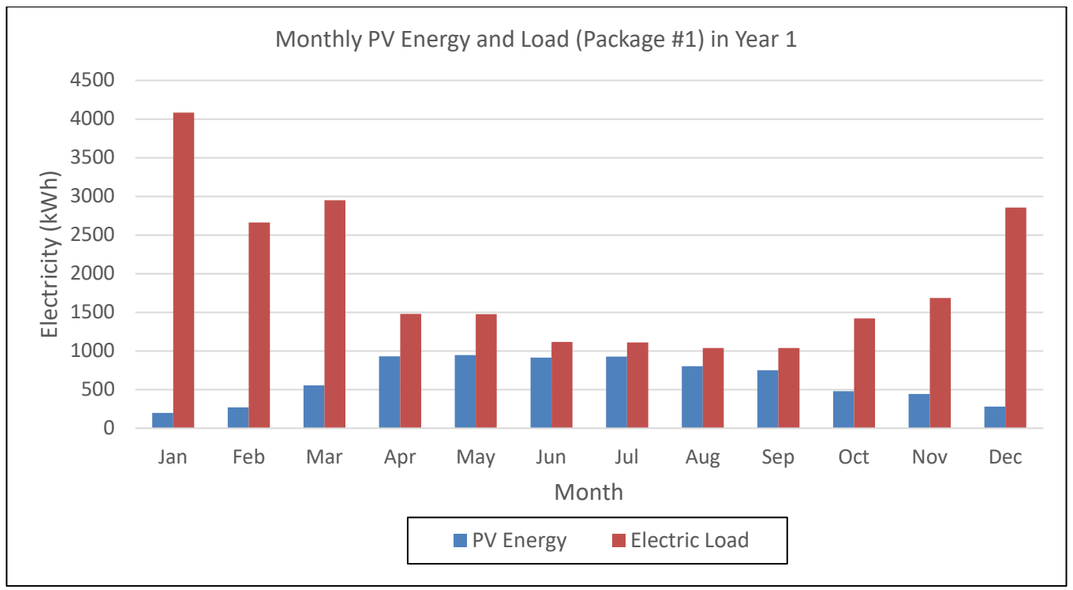
Rooftop Solar

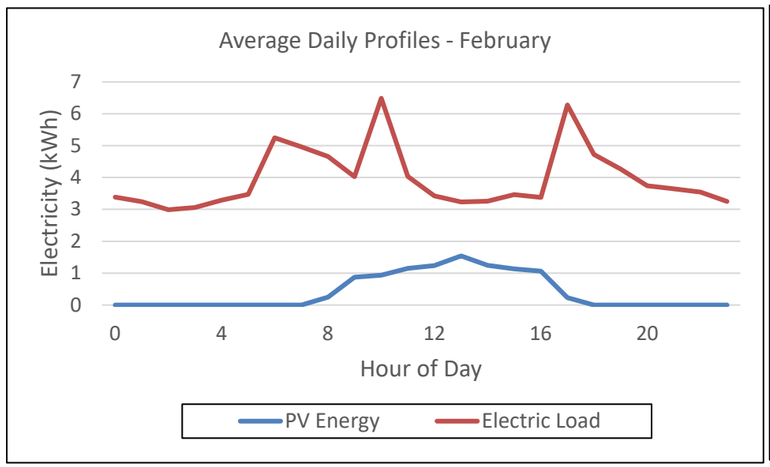
- Total PV generation (year 1): **7,499 kWh (1,154 kWh/kWdc)**
- Annual building electric load: **22,911 kWh**
- Total fraction of electric load met (year 1): **32.7%**
- Direct fraction of electric load met (year 1): **21.6%**
- Electricity cost without PV (year 1): $**2,615**
- Utility cost savings (w/ net metering) (year 1): **$1,092**
- Utility cost savings (w/o net metering) (year 1): **$721**
- System size: **6.5 kWdc**

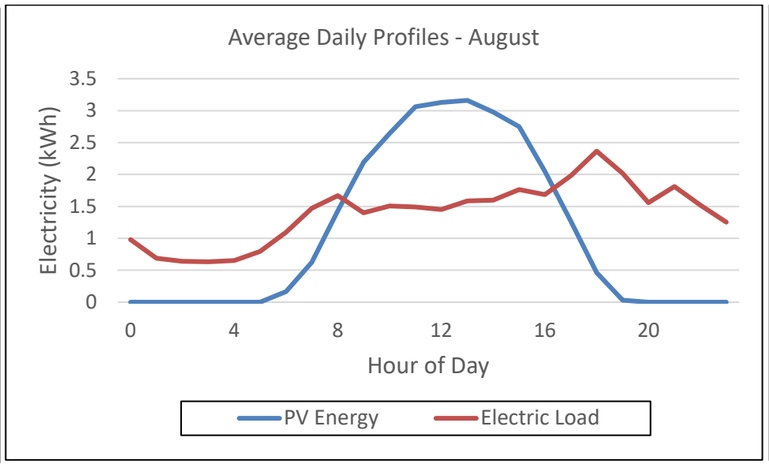
Annualized cost savings (w/ net metering): **$325**
Annualized cost savings (w/o net metering): **-$46**

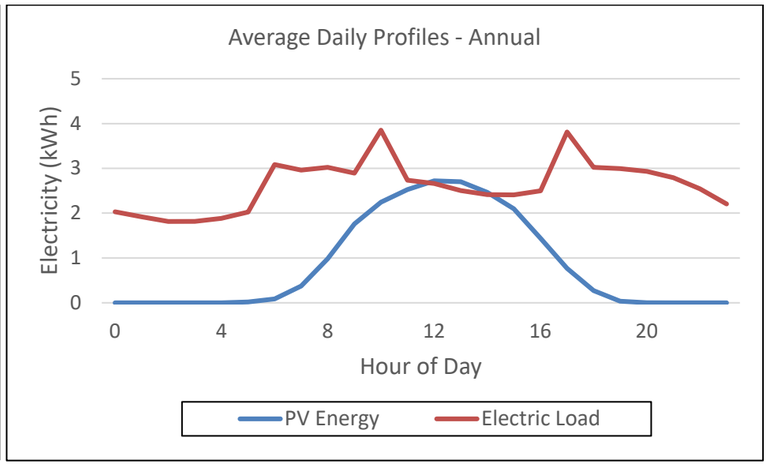
Solar Hot Water

- Estimated annual site energy savings: **7.0%**
- Utility cost savings: **$228/yr**
- Annualized cost savings: **-$354/yr**









5.35 Climate Zone 7 – Anchorage, AK (Natural Gas Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Natural Gas Rate: $0.921/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.213
500–1000	$ 0.199
1000–1500	$ 0.194
1500+	$ 0.192

Alaska Building Energy Efficiency Standard (BEES) baseline home which adheres to a more aggressive EE design:

Category	Option	BEES 2018, Zone 7
Envelope	Wood Stud	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass
	Radiant Barrier	None
	Slab	4ft R15 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard
	Water Heater	Gas Standard
	Central Air Conditioner	SEER 14
	Furnace	Gas, 80% AFUE
	Lighting	100% CFL
Energy & Cost Metrics	Ann. Energy Costs ($/yr)	3,313
	Source Energy Use (MMBtu/yr)	248.8

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-10 XPS	R-10 XPS	R-5 XPS	R-15 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R15 Exterior XPS	4ft R10 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	2 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ERV, 70% SRE
	Water Heater	Gas Standard	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82
	Central Air Conditioner	SEER 14	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)	SEER 16 (2 Stage)
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 98% AFUE	Gas, 80% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	15.8%	16.7%	16.6%	15.6%	17.8%
	Ann. Energy Costs ($/yr)	3,229	2,982	3,000	3,000	3,031	3,077
	Ann. Energy Costs Savings (%)	0.0%	7.7%	7.1%	7.1%	6.1%	4.7%
	Source Energy Use (MMBtu/yr)	238.8	206.4	205.0	204.9	207.2	204.2

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

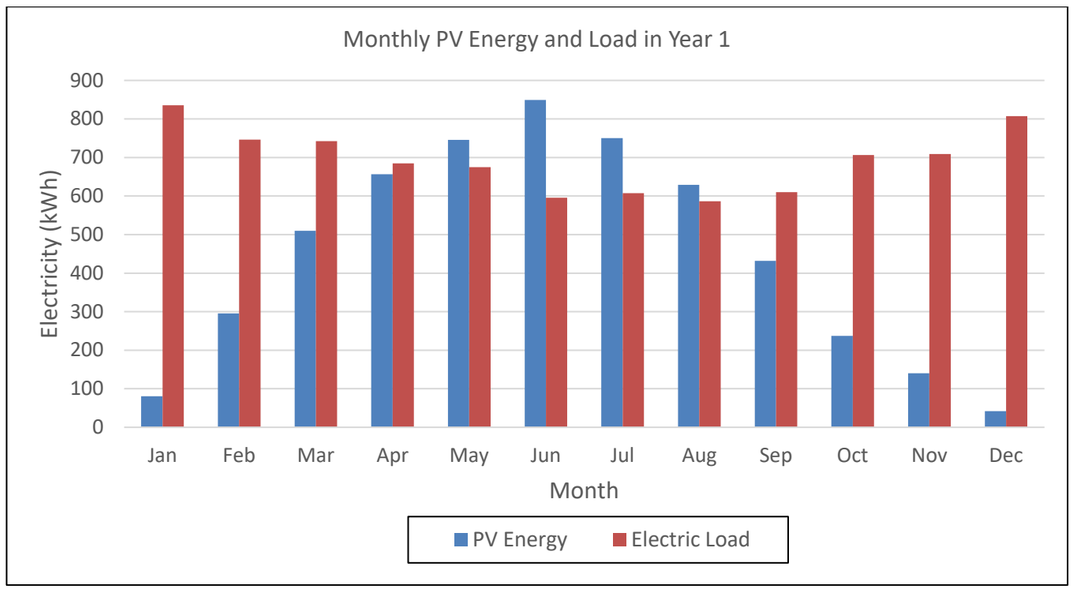
Rooftop Solar

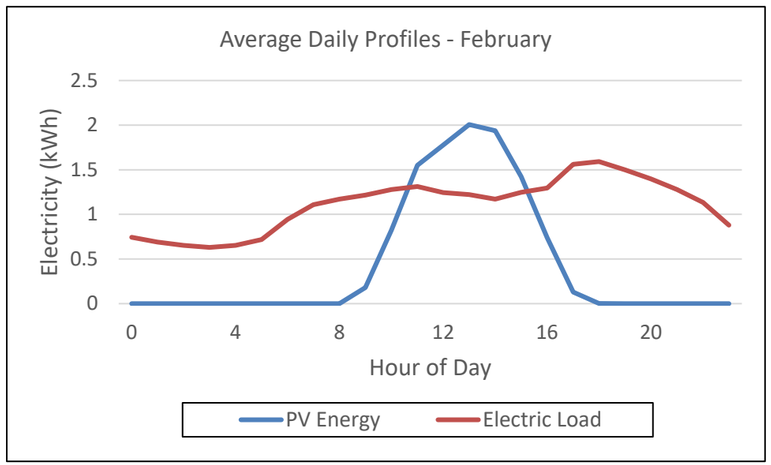
- Total PV generation (year 1): **5,369 kWh (826 kWh/kWdc)**
- Annual building electric load: **8,306 kWh**
- Total fraction of electric load met (year 1): **64.6%**
- Direct fraction of electric load met (year 1): **34.5%**
- Electricity cost without PV (year 1): $**1,737**
- Utility cost savings (w/ net metering) (year 1): **$1,121**
- Utility cost savings (w/o net metering) (year 1): **$588**
- System size: **6.5 kWdc**

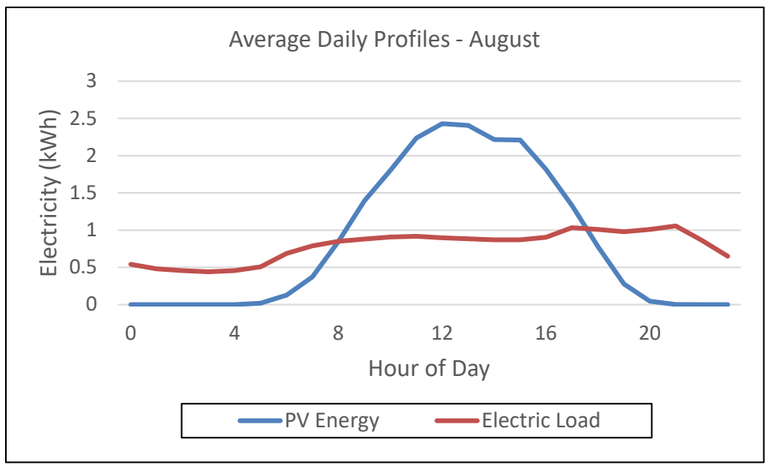
Annualized cost savings (w/ net metering): **$354**
Annualized cost savings (w/o net metering): **-$179**

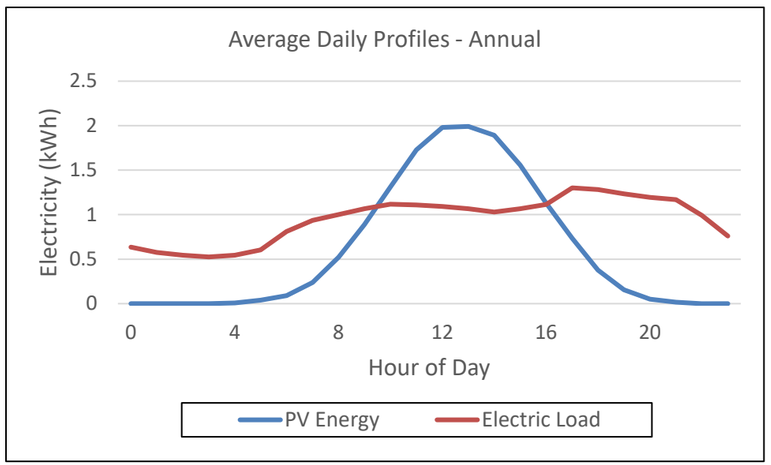
Solar Hot Water

- Estimated annual site energy savings: **6.8%**
- Utility cost savings: **$65/yr**
- Annualized cost savings: **-$517/yr**









5.36 Climate Zone 7 – Anchorage, AK (Electric Heating)

Energy Efficiency Packages

Model Details:

Heating Fuel: Electric
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Slab
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.213
500–1000	$ 0.199
1000–1500	$ 0.194
1500+	$ 0.192

Alaska Building Energy Efficiency Standard (BEES) baseline home which adheres to a more aggressive EE design:

Category	Option	BEES 2018, Zone 7
Envelope	Wood Stud	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-5 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass
	Radiant Barrier	None
	Slab	4ft R15 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard
	Water Heater	Gas Standard
	Air Source Heat Pump	None
	Central Air Conditioner	SEER 13
	Furnace	Electric, 100% AFUE
	Lighting	100% CFL
Energy & Cost Metrics	Ann. Energy Costs ($/yr)	8,068
	Source Energy Use (MMBtu/yr)	384.0

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	Wood Stud	R-13 Fiberglass, 2x4, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-19 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"	R-21 Fiberglass, 2x6, 16"
	Wall Sheathing	R-10 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-15 XPS	R-10 XPS
	Unfinished Attic	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass	Ceiling R-60 Fiberglass
	Radiant Barrier	None	None	None	None	None	None
	Slab	4ft R10 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R20 Exterior XPS	4ft R15 Exterior XPS	4ft R20 Exterior XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.21, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Electric Tank, UEF=0.92	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45	HPWH, 50 gal, UEF=3.45
	Air Source Heat Pump	None	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF	SEER 22, 10 HSPF
	Central Air Conditioner	SEER 13	None	None	None	None	None
	Furnace	Electric, 100% AFUE	None	None	None	None	None
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	53.9%	53.7%	53.7%	53.7%	53.6%
	Ann. Energy Costs ($/yr)	8,197	4,688	4,694	4,696	4,697	4,703
	Ann. Energy Costs Savings (%)	0.0%	42.8%	42.7%	42.7%	42.7%	42.6%
	Source Energy Use (MMBtu/yr)	390.4	180.1	180.7	180.6	180.9	181.3

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

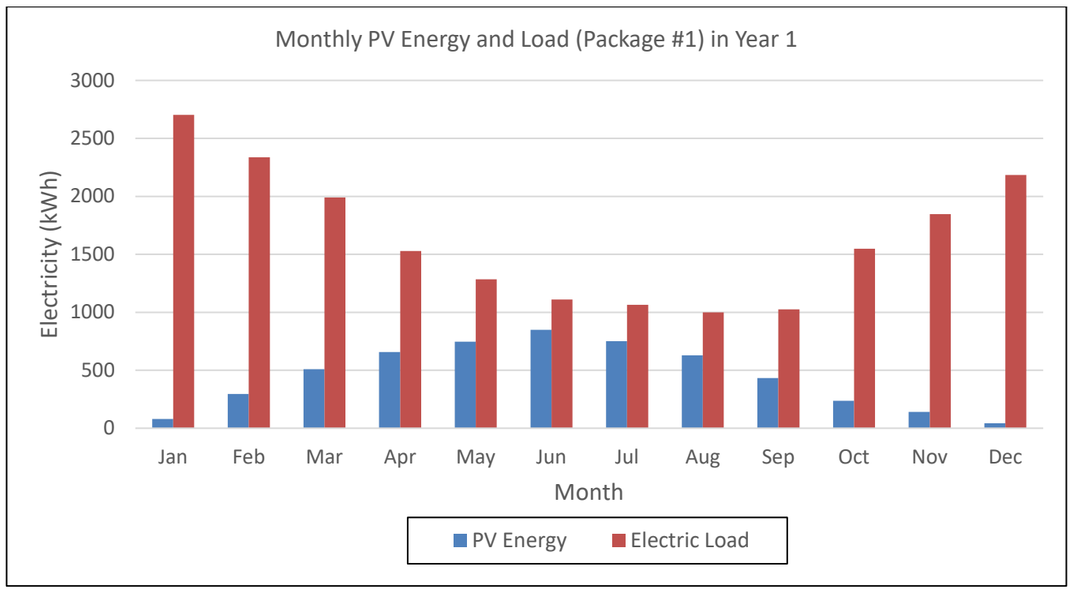
Rooftop Solar

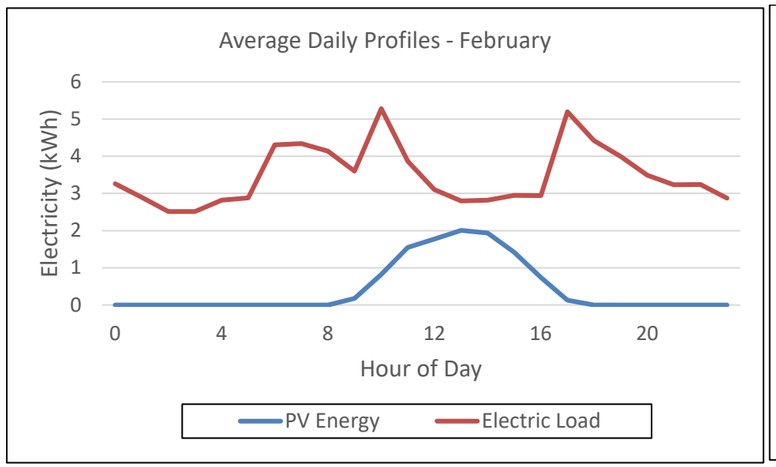
- Total PV generation (year 1): **5,369 kWh (826 kWh/kWdc)**
- Annual building electric load: **19,621 kWh**
- Total fraction of electric load met (year 1): **27.4%**
- Direct fraction of electric load met (year 1): **19.9%**
- Electricity cost without PV (year 1): $**3,943**
- Utility cost savings (w/ net metering) (year 1): **$1,076**
- Utility cost savings (w/o net metering) (year 1): **$765**
- System size: **6.5 kWdc**

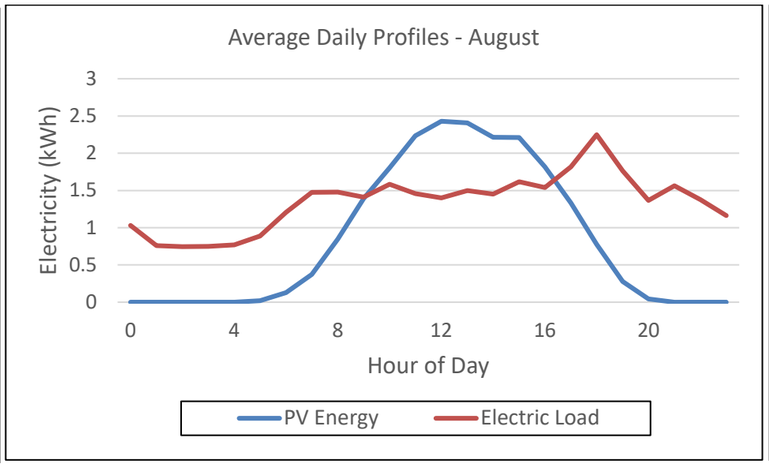
Annualized cost savings (w/ net metering): **$309**
Annualized cost savings (w/o net metering): **-$2**

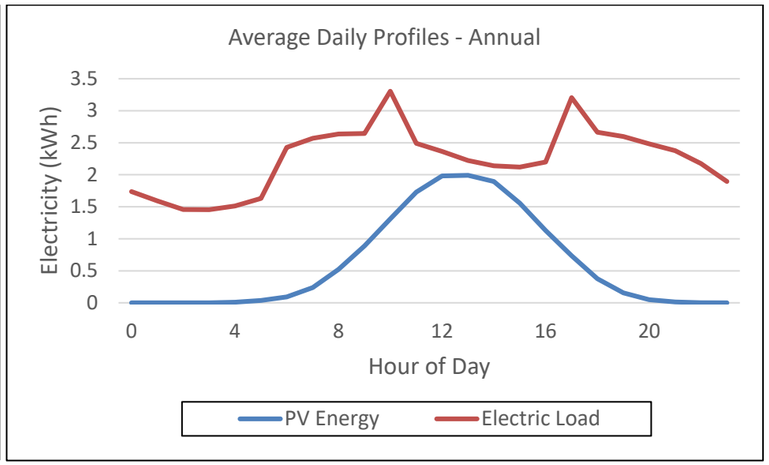
Solar Hot Water

- Estimated annual site energy savings: **6.5%**
- Utility cost savings: **$259/yr**
- Annualized cost savings: **-$323/yr**









5.37 Climate Zone 8 – Utqiagvik, AK (Fuel Oil Heating)

Energy Efficiency Packages

NOTE: A cost multiplier of 3 was applied to materials for Utqiagvik to account for increased transportation costs

Model Details:

Heating Fuel: Fuel Oil
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Raised Foundation
Fuel Oil Rate: $3.17/gal
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.213
500–1000	$ 0.199
1000–1500	$ 0.194
1500+	$ 0.192

Alaska Building Energy Efficiency Standard (BEES) baseline home which adheres to a more aggressive EE design:

Category	Option	BEES 2018, Zone 9
Envelope	SIP Wall	7.4 in EPS Core, OSB
	Finished Roof	R-38 Fiberglass
	Raised Foundation	R-38 Fiberglass
	Windows	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard
	Water Heater	Fuel Oil Tank, EF=0.63
	Heater	Fuel Oil Heater 87% AFUE
	Lighting	100% CFL
Energy & Cost Metrics	Ann. Energy Costs ($/yr)	9,816
	Source Energy Use (MMBtu/yr)	495.6

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	SIP Wall	3.6 in EPS Core, OSB	9.4 in EPS Core, OSB	7.4 in EPS Core, OSB	9.4 in EPS Core, OSB	9.4 in EPS Core, OSB	9.4 in EPS Core, OSB
	Finished Roof	R-38 Fiberglass	R-38 Fiberglass + R-10 XPS	R-38 Fiberglass + R-15 XPS	R-38 Fiberglass + R-20 XPS	R-38 Fiberglass + R-10 XPS	R-38 Fiberglass + R-25 XPS
	Raised Foundation	R-38 Fiberglass	R-38 Fiberglass + R-10 XPS	R-38 Fiberglass + R-15 XPS	R-38 Fiberglass + R-20 XPS	R-38 Fiberglass + R-15 XPS	R-38 Fiberglass + R-10 XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.18, SHGC = 0.40	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE	ASHRAE 62.2 Standard	ERV, 70% SRE	ERV, 70% SRE
	Water Heater	Fuel Oil Tank, UEF=0.62	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.67	Fuel Oil Tank, UEF=0.62	Fuel Oil Tank, UEF=0.67
	Heater	Fuel Oil Heater 87% AFUE	Fuel Oil Heater 87% AFUE	Fuel Oil Heater 87% AFUE	Fuel Oil Heater 87% AFUE	Fuel Oil Heater 87% AFUE	Fuel Oil Heater 87% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	46.5%	46.3%	46.7%	45.6%	45.0%
	Ann. Energy Costs ($/yr)	10,887	7,631	7,665	7,706	7,716	7,729
	Ann. Energy Costs Savings (%)	0.0%	29.9%	29.6%	29.2%	29.1%	29.0%
	Source Energy Use (MMBtu/yr)	551.0	316.6	317.5	313.4	320.5	324.2

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

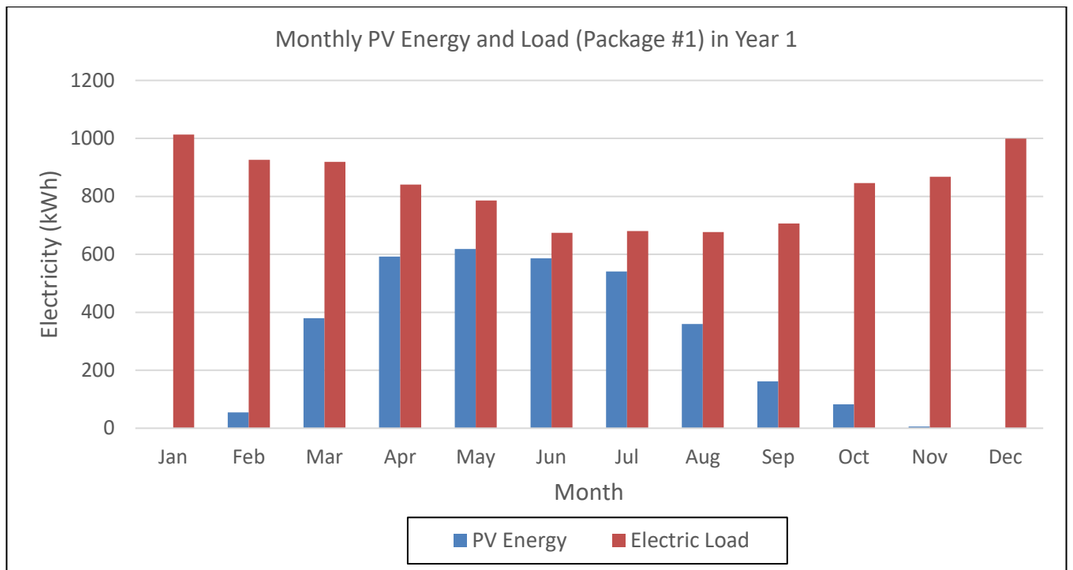
Rooftop Solar

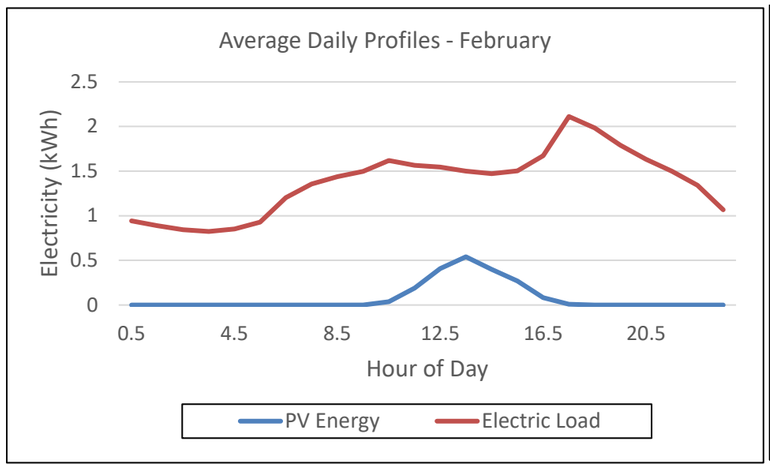
- Total PV generation (year 1): **3,381 kWh (520 kWh/kWdc)**
- Annual building electric load: **9,934 kWh**
- Total fraction of electric load met (year 1): **34.0%**
- Direct fraction of electric load met (year 1): **25.4%**
- Electricity cost without PV (year 1): $**2,061**
- Utility cost savings (w/ net metering) (year 1): **$696**
- Utility cost savings (w/o net metering) (year 1): **$512**
- System size: **6.5 kWdc**

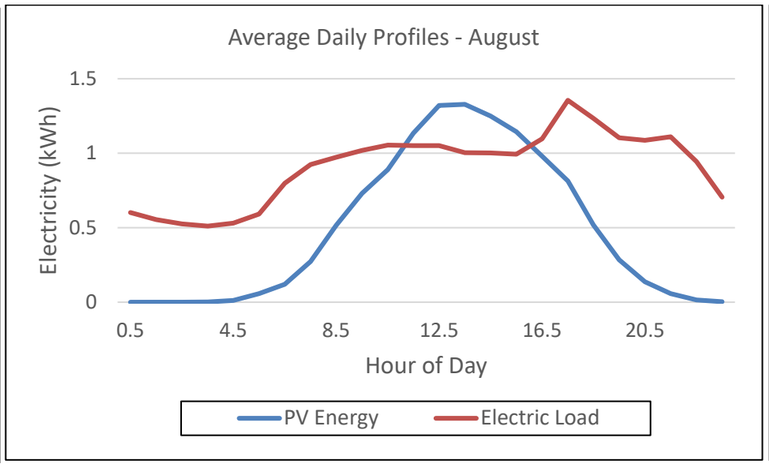
Annualized cost savings (w/ net metering): **-$71**
Annualized cost savings (w/o net metering): **-$255**

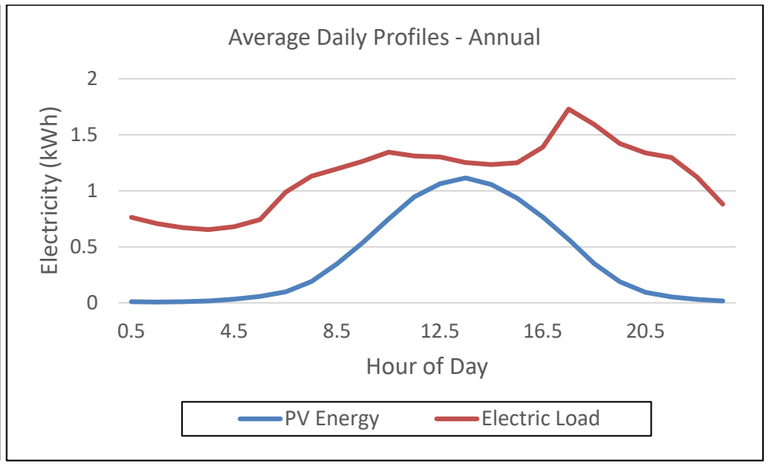
Solar Hot Water

- Estimated annual site energy savings: **2.5%**
- Utility cost savings: **$102/yr**
- Annualized cost savings: **-$1,359/yr**









5.38 Climate Zone 8 – Utqiagvik, AK (Natural Gas Heating)

Energy Efficiency Packages

NOTE: A cost multiplier of 3 was applied to materials for Utqiagvik to account for increased transportation costs

Model Details:

Heating Fuel: Natural Gas
Heating Setpoint: 69°F
Cooling Setpoint: 71°F
Foundation Type: Raised Foundation
Natural Gas Rate: $0.921/therm
Electricity Rate:

kWh Range	Rate ($/kWh)
0–500	$ 0.213
500–1000	$ 0.199
1000–1500	$ 0.194
1500+	$ 0.192

Alaska Building Energy Efficiency Standard (BEES) baseline home which adheres to a more aggressive EE design:

Category	Option	BEES 2018, Zone 9
Envelope	SIP Wall	7.4 in EPS Core, OSB
	Finished Roof	R-38 Fiberglass
	Raised Foundation	R-38 Fiberglass
	Windows	U = 0.30, SHGC = 0.38
	Air Leakage	3 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, EF=0.63
	Furnace	Gas, 80% AFUE
	Lighting	100% CFL
Energy & Cost Metrics	Ann. Energy Costs ($/yr)	5,458
	Source Energy Use (MMBtu/yr)	473.4

Category	Option	Code Min. (IECC 2021)	Package 1	Package 2	Package 3	Package 4	Package 5
Envelope	SIP Wall	3.6 in EPS Core, OSB	5.6 in EPS Core, OSB	5.6 in EPS Core, OSB	7.4 in EPS Core, OSB	7.4 in EPS Core, OSB	7.4 in EPS Core, OSB
	Finished Roof	R-38 Fiberglass	R-38 Fiberglass	R-38 Fiberglass	R-38 Fiberglass + R-5 XPS	R-38 Fiberglass	R-38 Fiberglass
	Raised Foundation	R-38 Fiberglass	R-38 Fiberglass	R-38 Fiberglass	R-38 Fiberglass	R-38 Fiberglass + R-5 XPS	R-38 Fiberglass + R-5 XPS
	Windows	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.30, SHGC = 0.38	U = 0.29, SHGC = 0.38
	Air Leakage	3 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50	1 ACH50
Eqpt. & Lighting	Ducts	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space	In Conditioned Space
	Mechanical Ventilation	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ASHRAE 62.2 Standard	ERV, 70% SRE	ASHRAE 62.2 Standard
	Water Heater	Gas Tank, UEF=0.62	Gas Tankless, UEF=0.82	Gas Tankless, Cond. UEF=0.96	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82	Gas Tankless, UEF=0.82
	Furnace	Gas, 80% AFUE	Gas, 90% AFUE	Gas, 90% AFUE	Gas, 95% AFUE	Gas, 90% AFUE	Gas, 98% AFUE
	Lighting	100% CFL	100% LED	100% LED	100% LED	100% LED	100% LED
Energy & Cost Metrics	Site Energy Savings (%)	0.0%	38.0%	39.1%	43.8%	44.1%	45.0%
	Ann. Energy Costs ($/yr)	5,969	4,322	4,421	4,449	4,468	4,485
	Ann. Energy Costs Savings (%)	0.0%	27.6%	25.9%	25.5%	25.2%	24.9%
	Source Energy Use (MMBtu/yr)	526.7	343.8	338.8	316.4	316.7	310.6

Code Minimum

Most Efficient

Rooftop PV and Solar Hot Water Analysis

NOTE: These analyses use electric loads from the *Package 1* design above and assumptions described in Section 3.2. A project-specific analysis should be performed to refine these estimates (App. C.1)

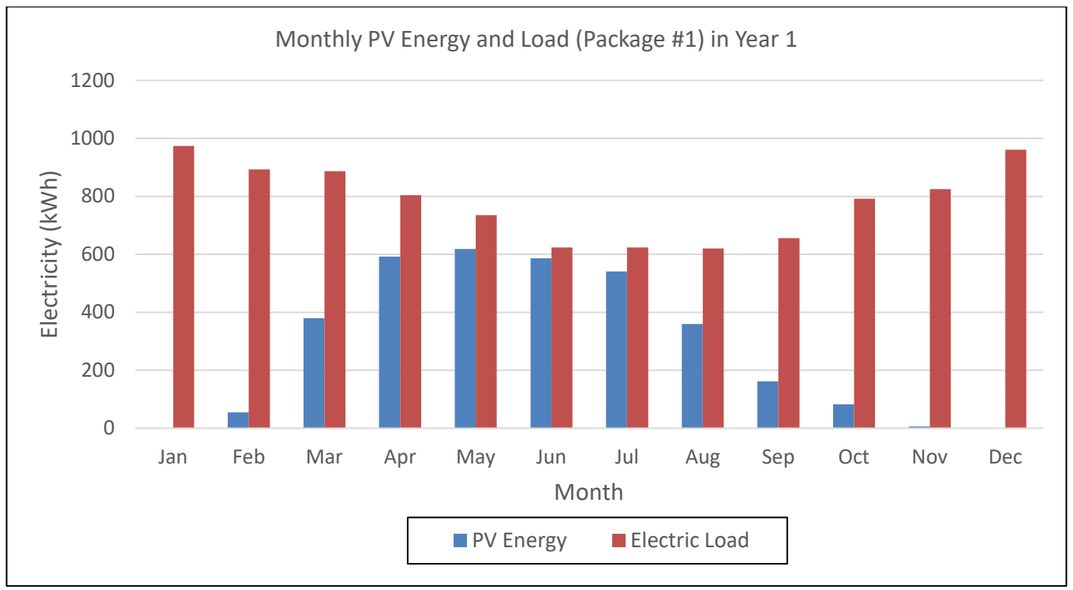
Rooftop Solar

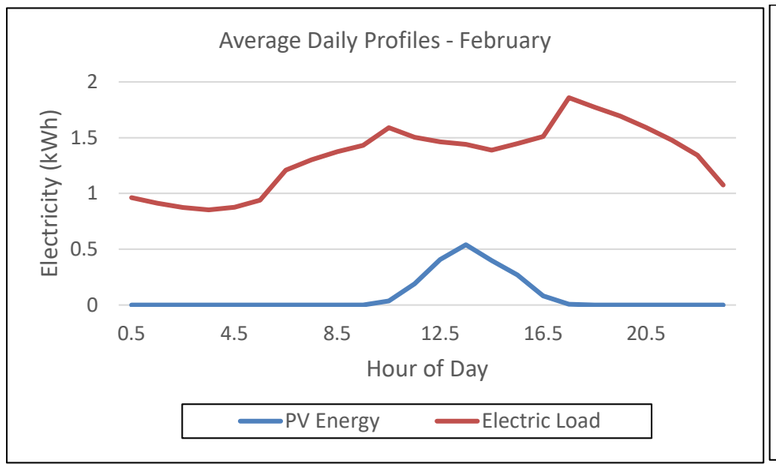
- Total PV generation (year 1): **3,381 kWh (520 kWh/kWdc)**
- Annual building electric load: **9,391 kWh**
- Total fraction of electric load met (year 1): **36.0%**
- Direct fraction of electric load met (year 1): **25.8%**
- Electricity cost without PV (year 1): $**1,953**
- Utility cost savings (w/ net metering) (year 1): **$699**
- Utility cost savings (w/o net metering) (year 1): **$494**
- System size: **6.5 kWdc**

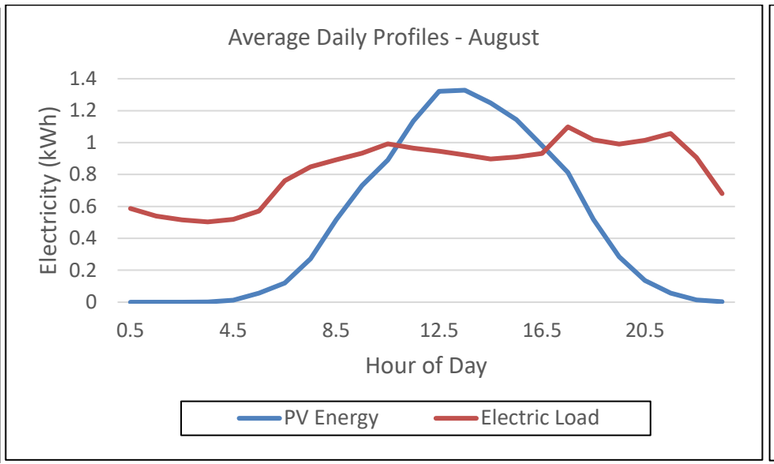
Annualized cost savings (w/ net metering): **-$68**
Annualized cost savings (w/o net metering): **-$273**

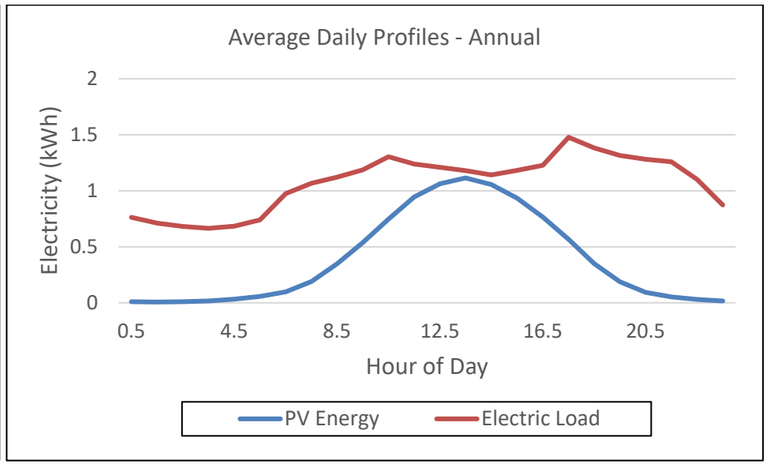
Solar Hot Water

- Estimated annual site energy savings: **2.5%**
- Utility cost savings: **$37/yr**
- Annualized cost savings: **-$1,424/yr**









6 Energy Resilience Potential Results

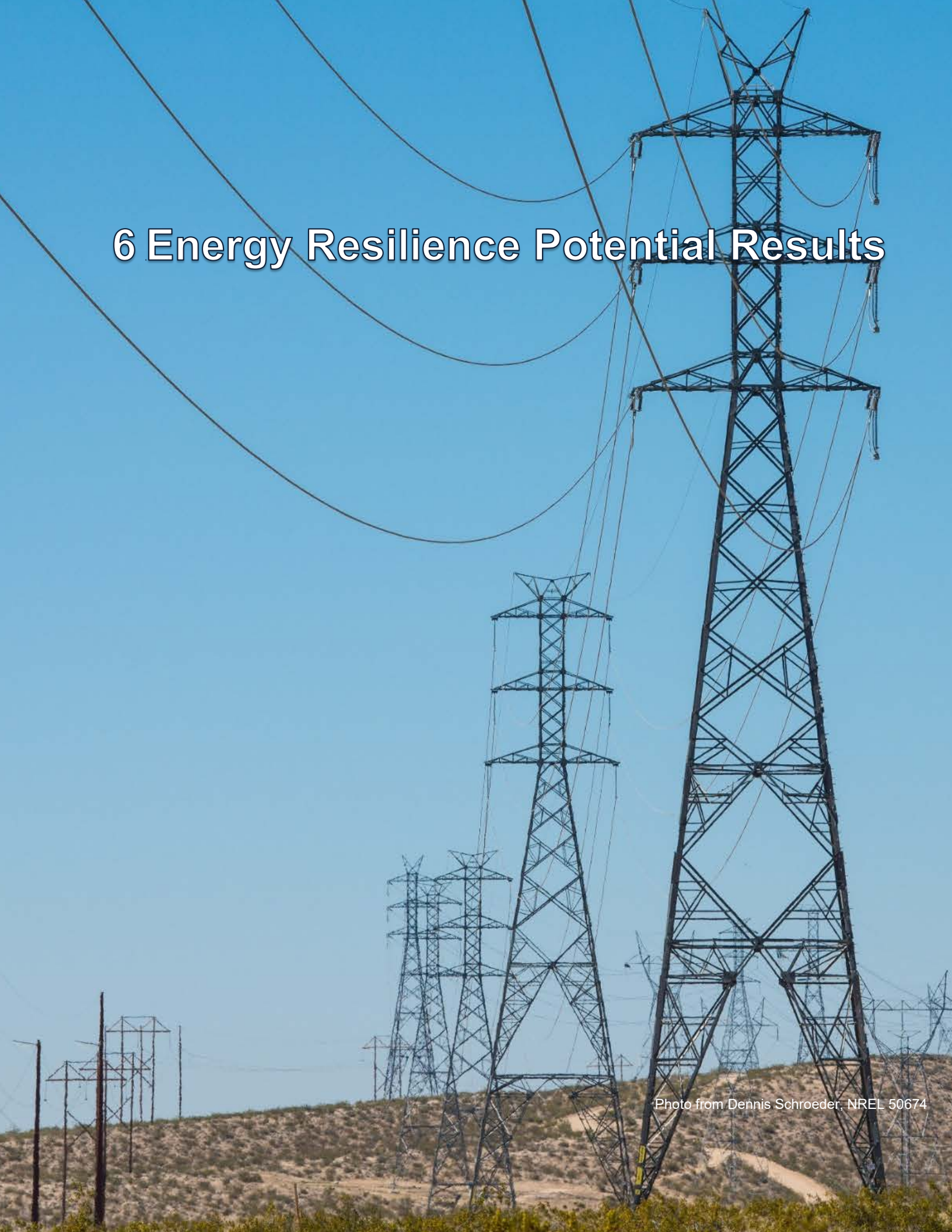


Photo from Dennis Schroeder, NREL 50674

6.1 Climate Zone 2B – Sells, AZ (June 2017)

We simulated the code minimum and the first package of the Sells, AZ (Electric Heating) case during a seven-day period overlapping a heat wave in the region. The metrics for this resiliency analysis quantify the cooling energy savings during this period and indoor temperature differences between the EE case and the baseline code minimum case.

Table 7. Energy resilience metrics for Sells, AZ

	7-Day Cooling Energy (kWh)			Unmet Degree-Hours[a]			Average Zone Temp during Outage (F)		
Outage Length (hrs)	Code Min	EE Package	% Change	Code Min	EE Package	% Change	Code Min	EE Package	% Change
None	153.0	137.1	-10%	8.4	4.6	-45%	N/A	N/A	N/A
12	151.6	135.1	-11%	9.0	5.1	-43%	77.2	77.0	-0.2%
24	140.5	126.0	-10%	20.6	12.9	-38%	79.6	78.7	-1.1%
120	51.3	48.9	-5%	61.1	42.7	-30%	85.0	83.5	-1.8%

[a] Unmet degree-hours is calculated as the sum of the differences between the zone temperature and the zone temperature setpoint across each hour of the outage.

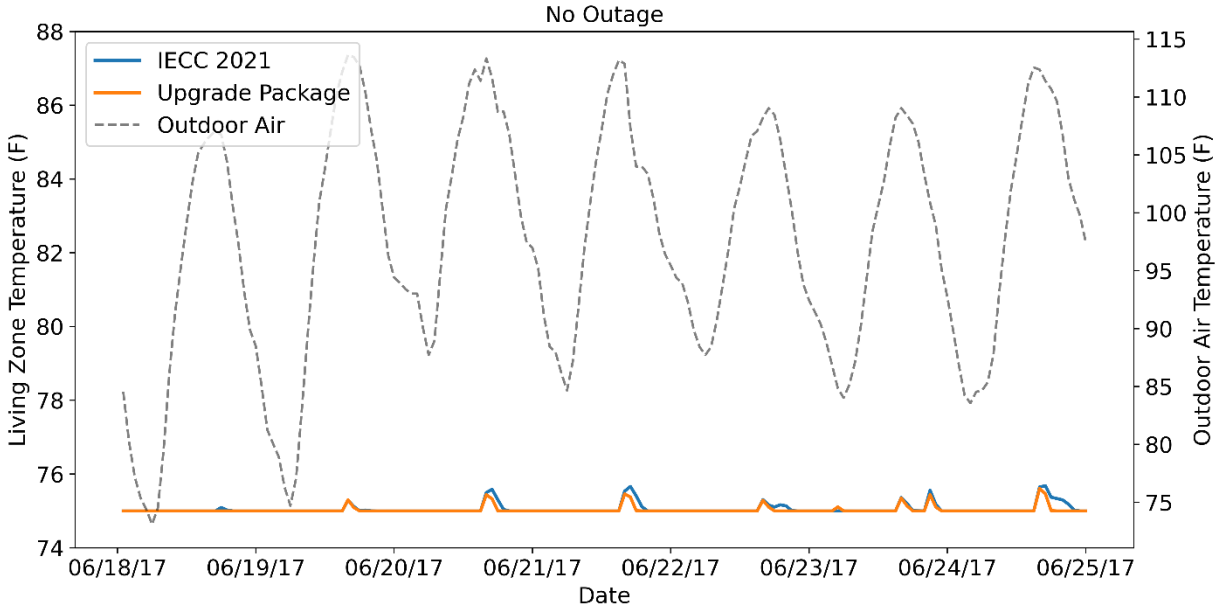


Figure 16. Modeled zone and outdoor temperatures during a heat wave in Sells, AZ. The cooling system is mostly able meet desired setpoint of 75°F in both designs.[6]

[6] A calculation consistent with ACCA's Manual J 8th Edition (ACCA 2016) is performed to size the cooling system in each design, and therefore cooling system sizes differ between home designs.

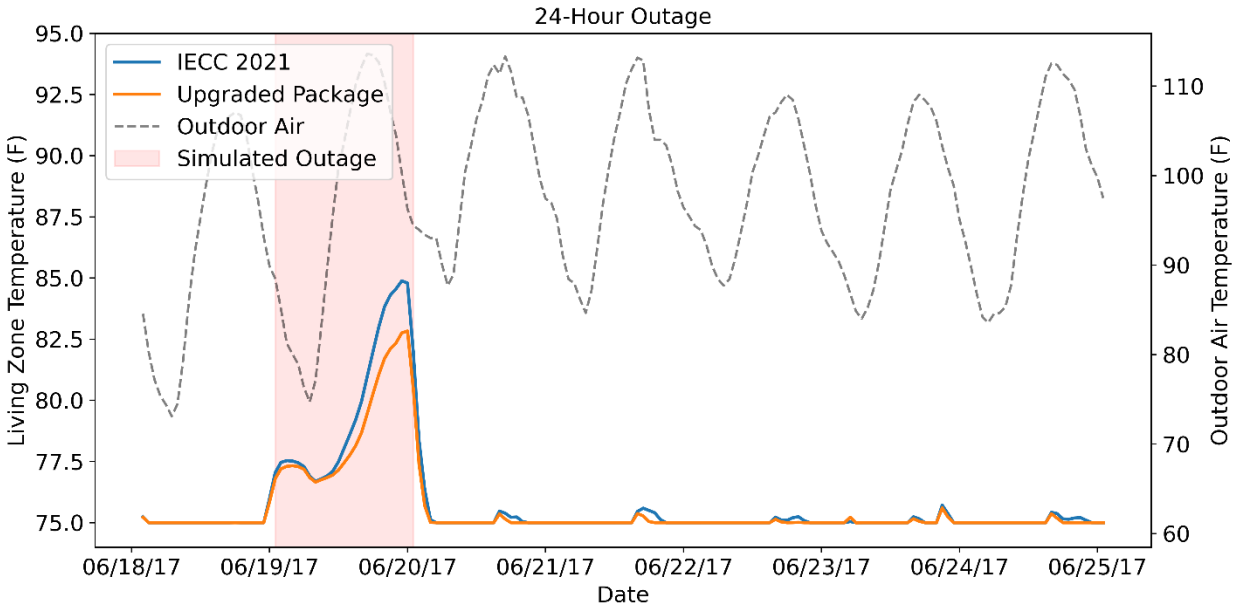


Figure 17. Zone and outdoor temperatures during a heat wave with a simulated 24-hr outage in Sells, AZ. The indoor temperature of the less-efficient design starts to diverge from the EE design as outdoor temperature increases.

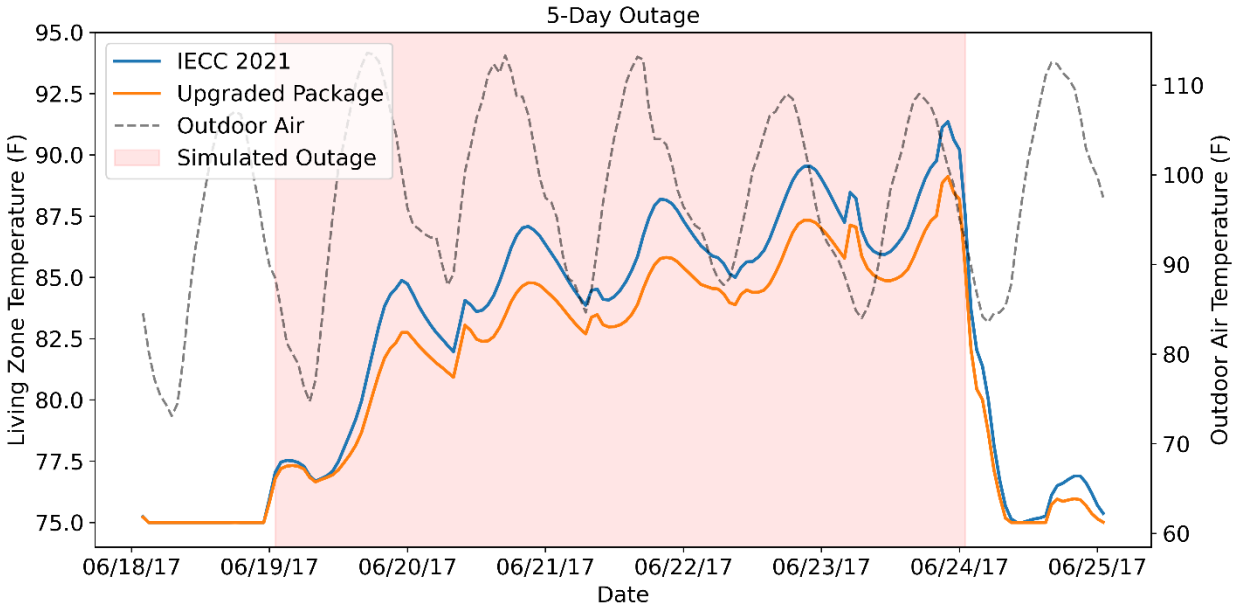


Figure 18. Zone and outdoor temperatures during a heat wave with a simulated 5-day outage in Sells, AZ. During the outage, indoor temperature differs between building designs by approximately 1°F in the evenings to over 2°F following the hottest part of the day.

6.2 Climate Zone 7A - Bemidji, MN (January 2019)

We simulated the code minimum and the first package of the Bemidji, MN (Natural Gas Heating) case during a seven-day period overlapping a poler vortex event in the region. The metrics for this resiliency analysis quantify the heating energy savings during this period and indoor temperature differences between the EE case and the baseline code minimum case.

	7-Day NG Heating Energy (therm)			Unmet Degree-Hours[a]			Average Zone Temp during Outage (F)		
Outage Length (hrs)	Code Min	EE Package	% Change	Code Min	EE Package	% Change	Code Min	EE Package	% Change
None	73.3	49.9	-32%	115.3	100.9	-13%	N/A	N/A	N/A
12	70.3	47.7	-32%	189.5	136.6	-28%	58.0	62.3	-7.4%
24	66.0	44.8	-32%	284.7	209.0	-27%	54.3	60.1	-10.6%
120	21.8	14.6	-33%	535.5	427.0	-20%	41.1	49.2	-19.5%

[a] Unmet degree-hours is calculated as the sum of the differences between the zone temperature and the zone temperature setpoint across each hour of the outage.

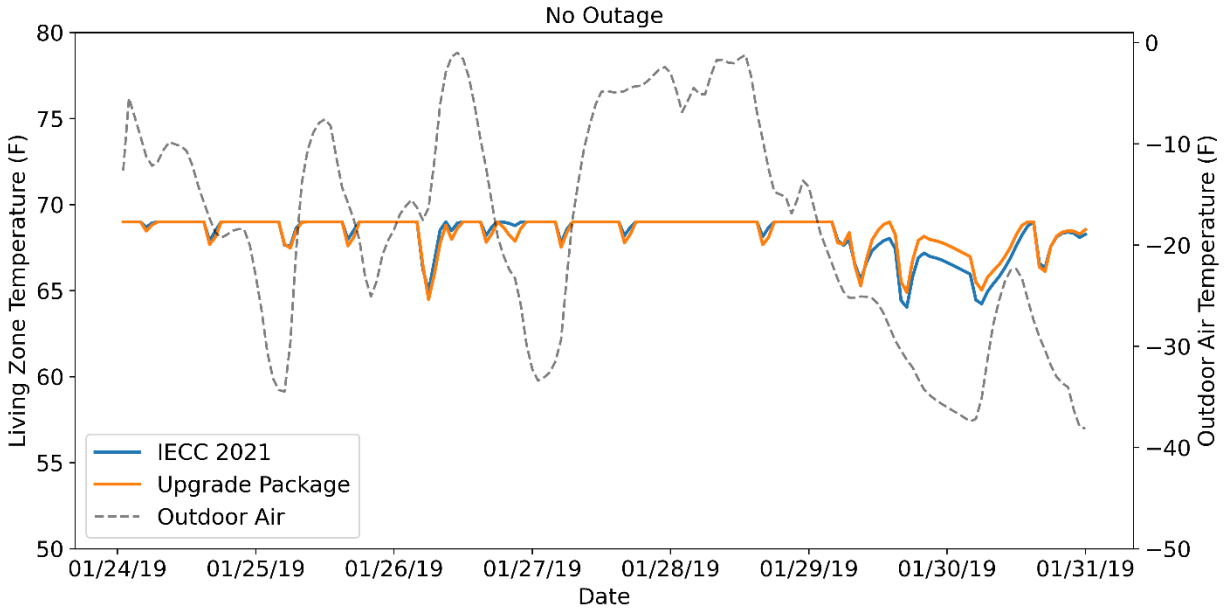


Figure 19. Zone and outdoor temperatures during a polar vortex event in Bemidji, MN. As the outdoor temperature reaches its coldest point near the end of the week, neither system is sized to be able to meet the setpoint of 69°F, however the EE design better maintains zone temperature.[7]

[7] A calculation consistent with ACCA's Manual J 8th Edition (ACCA 2016) is performed to size the heating system in each design, and therefore heating system sizes differ between home designs.

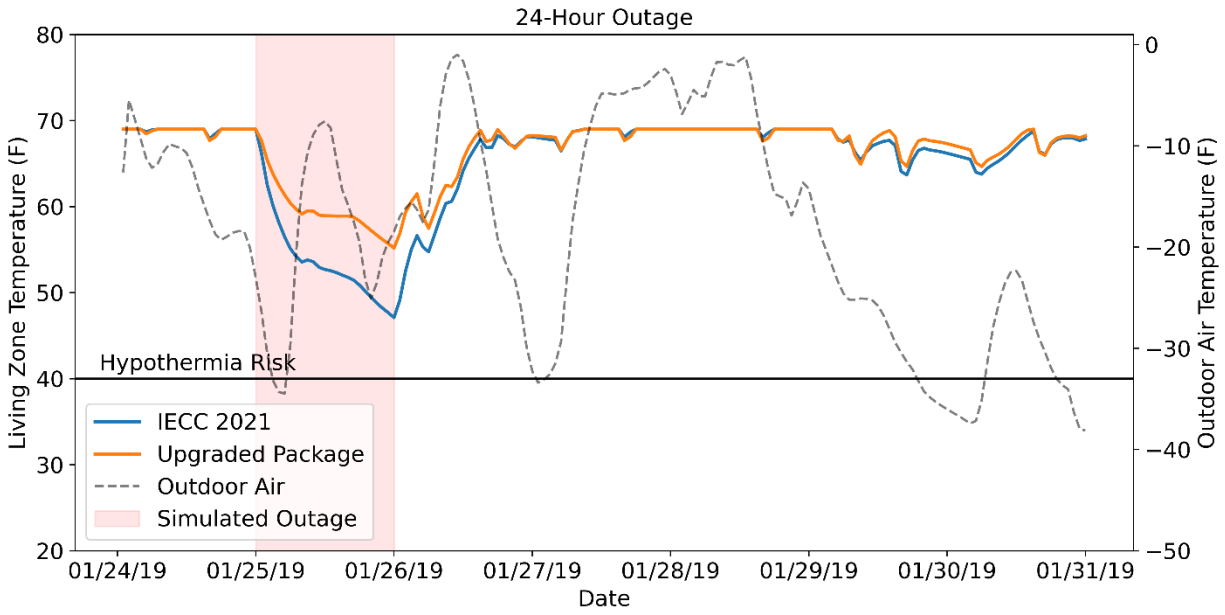


Figure 20. Zone and outdoor temperatures during a polar vortex event with a simulated 24-hour outage in Bemidji, MN. Indoor temperatures quickly diverge between the two building designs, with a peak difference of 6°F (53°F vs 59°F).

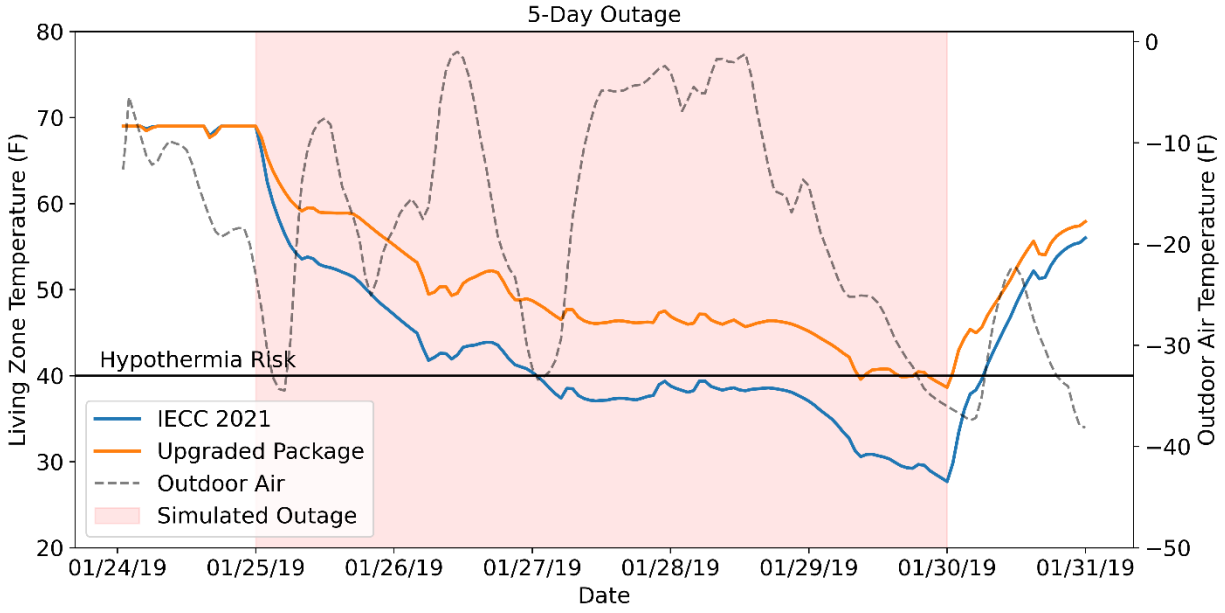


Figure 21. Zone and outdoor temperatures during a polar vortex event with a simulated 5-day outage in Bemidji, MN. During the outage, the EE design much more effectively maintains the indoor temperature compared to the baseline. The EE design is on average 8°F warmer and suggests a lesser risk of hypothermia for occupants.

7 Conclusions

Implementing energy-efficient measures into building designs is not a trivial task. During the design phase, it is difficult to find the best pathways that optimize for initial costs and payback time without robust energy modeling. During the build phase, challenges may originate from identifying specialized labor that can implement efficiency measures or sourcing materials and equipment that may not be common in the region. Pair this with the challenges associated with construction in remote locations, and many residential projects do not build beyond the minimum energy code. With this guide, we hope to streamline the process of incorporating energy efficiency into residential projects. Our recommendations consider EE options as packages that influence whole-home energy usage and account for the coupled effects between measures. This report demonstrates that there are often many pathways to achieving significant cost-effective reductions in the design phase, regardless of location or available fuel type.

We also provided initial assessments for potential of rooftop solar and solar hot water systems applied to the EE packages. When combined with energy efficiency measures, rooftop solar can effectively reduce a significant portion of the building load in many parts of the country. However, to exactly understand the cost benefits of a residential PV system, a more detailed study should be performed that can account for the local economics and policy surrounding residential solar power generation in that region. In general, commercially available solar hot water systems are not shown to be cost effective over the lifetime of the building, which is underscored by the fact that they may be competing against PV systems for available roof area.

Finally, Section 6 demonstrates the effect that improved energy efficiency may have on the short-term energy resilience of the home. With the onset of more extreme weather conditions in many parts of the country, occupants may be left vulnerable if homes are not built for resilience, leading to potential health and safety concerns for vulnerable populations. Although package recommendations are not specifically designed for energy resilience, benefits of maintaining indoor temperatures and reducing energy demand during extreme heat and cold are likely possible. Further, in the event of outages that interrupt heating or cooling systems, improved envelope performance can extend indoor conditions that are safe for occupants.

Appendix A. Model Inputs

Table A-1. List of Locations, Heating Fuels, and Foundation Types Considered

IECC Climate Zone	City	IHS Area	Heating Fuel	Foundation Type
2B	Sells, AZ	Tucson	Electricity	Slab
2B	Sells, AZ	Tucson	Propane	Slab
2B	Parker, AZ	Phoenix	Electricity	Slab
2B	Parker, AZ	Phoenix	Propane	Slab
3A	Rock Hill, SC	Nashville	Electricity	Slab
3A	Rock Hill, SC	Nashville	Natural Gas	Slab
3B	Peach Springs, AZ	Phoenix	Electricity	Slab
3B	Peach Springs, AZ	Phoenix	Natural Gas	Slab
3C	Ukiah, CA	California	Natural Gas	Slab
3C	Ukiah, CA	California	Propane	Slab
4A	White Cloud, KS	Oklahoma	Natural Gas	Slab
4A	White Cloud, KS	Oklahoma	Propane	Slab
4B	San Fidel, NM	Albuquerque	Natural Gas	Slab
4B	San Fidel, NM	Albuquerque	Electricity	Slab
4C	Salem, OR	Portland	Electricity	Vented Crawlspace
4C	Salem, OR	Portland	Natural Gas	Vented Crawlspace
5A	Rosebud, SD	Great Plains	Electricity	Slab
5A	Rosebud, SD	Great Plains	Propane	Slab
5B	Dulce, NM	Albuquerque	Natural Gas	Slab
5B	Dulce, NM	Albuquerque	Electricity	Slab
5B	Warm Springs, OR	Portland	Electricity	Slab
5B	Warm Springs, OR	Portland	Natural Gas	Slab
5B	Window Rock, AZ	Navajo	Electricity	Slab
5B	Window Rock, AZ	Navajo	Propane	Slab
6A	Eagle Butte, SD	Great Plains	Electricity	Heated Basement
6A	Eagle Butte, SD	Great Plains	Propane	Heated Basement
6B	Crow Agency, MT	Billings	Natural Gas	Heated Basement
6B	Crow Agency, MT	Billings	Propane	Heated Basement
6B	Ft Washakie, WY	Billings	Natural Gas	Heated Basement
6B	Ft Washakie, WY	Billings	Propane	Heated Basement
7A	Bemidji, MN	Bemidji	Natural Gas	Heated Basement
7A	Bemidji, MN	Bemidji	Electricity	Heated Basement
7A	Belcourt, ND	Great Plains	Electricity	Heated Basement
7A	Belcourt, ND	Great Plains	Fuel Oil	Heated Basement
7	Anchorage, AK	Alaska	Natural Gas	Slab
7	Anchorage, AK	Alaska	Electricity	Slab

IECC Climate Zone	City	IHS Area	Heating Fuel	Foundation Type
8	Utqiagvik, AK	Alaska	Natural Gas	Raised Foundation
8	Utqiagvik, AK	Alaska	Fuel Oil	Raised Foundation

Table A-2. Data Sources for Baseline Building Energy Models

Building Characteristic	Source
Envelope insulation	IECC 2021
Air leakage	IECC 2021
Mechanical ventilation rate	IECC 2021 (ASHRAE 62.2)
Ducts	IECC 2021 (additional efficiency package options)
Mechanical ventilation equipment type	(Boyer 2021)
Water heater efficiency	10 CFR Part 430
Appliance efficiency	10 CFR Part 430
HVAC efficiency	10 CFR Part 430
Construction materials (e.g., siding)	ResStock v2.5.0™[a]
Heating and cooling setpoints	ResStock v2.5.0™[a]
Foundation type	ResStock v2.5.0™[a]
Wall type	Indian Health Service
Fuel type (for heating and water heating)	Indian Health Service
Option costs[a]	NREMDB v3.1.0[b]
Utility rates	Indian Health Service
Source-to-site ratio	ENERGY STAR Portfolio Manager 2020 (ENERGY STAR 2020)
Weather data	TMY3 Files (Wilcox 2008)

[a] https://resstock.nrel.gov/
[b] Costs for water heaters were supplemented by This Old House Reviews Team 2022 and Less 2022
[c] https://remdb.nrel.gov/

Table A-3. Annual Snow Cover Loss Factors Used in Rooftop PV Modeling

Location	State	Climate Zone	Representative City[a]	Annual Snow Loss Factor[a]
Sells	AZ	2B	-	-
Parker	AZ	2B	-	-
Rock Hill	SC	3A	-	-
Peach Springs	AZ	3B	-	-
Ukiah	CA	3C	-	-
White Cloud	KS	4A	Kansas City, MO	3.7%
San Fidel	NM	4B	-	-
Salem	OR	4C	-	-
Rosebud	SD	5A	Pierre, SD	6.7%
Window Rock	AZ	5B	Grand Junction, CO	2.6%
Warm Springs	OR	5B	Redmond, OR	1.7%
Dulce	NM	5B	Boulder, CO	5.5%
Eagle Butte	SD	6A	Pierre, SD	6.7%
Ft Washakie	WY	6B	Lander, WY	9.0%
Crow Agency	MT	6B	Billings, MT	7.7%
Bemidji	MN	7A	Rochester, MN	11.0%
Belcourt	ND	7A	Bismarck, ND	9.5%
Anchorage	AK	7	Anchorage, AK	7.1%
Utqiagvik	AK	8	Barrow, AK	33.0%

[a] From Appendix A of Ryberg and Freeman 2017

Appendix B. Detailed Methodologies

B.1 Identifying Energy Efficiency Packages

We identified cost-effective energy efficiency packages by modeling whole-home energy usage with the National Renewable Energy Laboratory's Building Energy Optimization Tool, or BEopt™. This program enables design of residential building geometry and energy-related inputs. Further, BEopt evaluates energy-efficient designs to identify cost-optimal packages over a given lifetime. The BEopt algorithm balances tradeoffs of energy efficiency measures by incorporating initial cost assumptions for individual building components as well as the local utility rates to minimize the lifetime energy costs of a home. This requires hundreds to thousands of building simulations to identify the mix of energy efficiency options that meet optimal or near-optimal conditions. The summary of steps taken to identify building designs are as follows:

1. Define the baseline 2021 IECC building using code inputs and other data sources described in Table A-2.
2. Select potential improvements with better energy performance than code minimum.
3. Optimize the set of home characteristics to minimize lifetime energy costs.
4. Identify the optimal and near-optimal packages that provide similar site energy and cost savings.
5. Select five near-optimal packages the maximize the diversity in options selected.

Building Inputs

A list of building characteristics and their corresponding data sources are shown in Table A-2. Energy efficiency inputs and equipment and appliance inputs for the baseline homes were sourced from IECC 2021 and 10 CFR Part 430, respectively. Envelope components were selected using the requirements prescribed in Table 402.1.3 of the IECC 2021. Some envelope components allow multiple pathways for code compliance. For the baseline wood frame walls, we assumed a 2x4 wall thickness with an R-13 cavity insulation, and continuous insulation added as needed based on the climate zone. For basement walls, we assumed continuous insulation applied to the exterior.

Other characteristics not prescribed in code were determined through the Indian Health Service offices directly or with the ResStock Analysis Tool™ v2.5.0[8]. ResStock is a tool that enables granular characterization of residential buildings by location and other dependencies (Wilson 2017). In our analysis, ResStock helps inform assumptions about housing characteristics that are most common to a location and heating fuel when such details are not known. Most of our cost assumptions in BEopt are sourced from the National Residential Efficiency Measures Database v3.1.0 (NREMDB).[9] To ensure up-to-date costs for water heaters, costs for tank water heater tank materials (This Old House Reviews Team 2022) and heat pump water heaters (Less 2022) were pulled from other sources. For homes with electric heating, the code minimum HVAC equipment was set to an electric furnace and a code minimum central A/C system, while HVAC upgrades for these homes were always air source heat pumps, as BEopt does not have the capability to run optimizations across HVAC equipment type.

[8] For more information, see https://resstock.nrel.gov/
[9] For more information, see https://remdb.nrel.gov/index.php.

BEopt Results

After defining baseline and upgrade options for a location and running the optimization, BEopt provides an optimization curve leading to the cost-minimum point. Each point on the curve represents a different design based on combinations of baseline and upgrade options selected. The objective function in BEopt minimizes the annualized energy cost for the length of the analysis period. This metric considers the incremental costs of each energy efficiency measure averaged across the analysis period and the utility costs to the occupants in each year, so that the tradeoffs of capital investment and operational costs can both be considered. We rely on this curve to select a subset of five packages that all have similar annual costs and site energy savings, or near-optimal points.

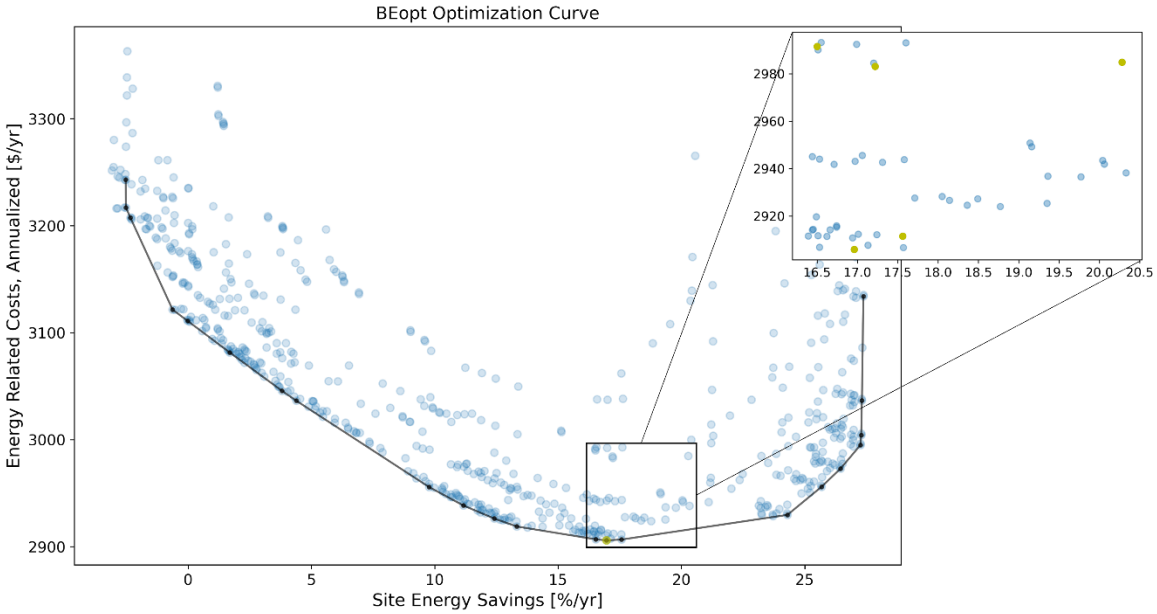


Figure 22. Example BEopt optimization with a zoomed in selection of near-optimal points

Each point represents a separate building design with unique inputs. The highlighted points are the selected energy efficiency packages.

A post-processing routine filtered the BEopt results to identify the near-optimal cluster of designs and the five EE packages (steps 4 and 5 of the methodology above). The set of potential designs from which the five designs were chosen were bound within 4% of the cost of the minimum point (y-axis of Figure 18) and from -3.5% to +25% of the energy savings relative to the cost minimum point (y-axis of Figure 18). From the cluster of near-optimal designs, packages were selected based on the relative diversity of the options. Starting from the cost-minimum point and ascending toward the highest cost package, points were selected based on the maximum number of different options from the already selected packages. This approach produces recommendations that span several of the option categories in Figure 7, and therefore provides more flexibility for building designers to customize their designs.

B.2 Rooftop PV and Solar Hot Water Technical Potential

We use the PVWatts model within NREL's System Advisor Model (SAM) to estimate rooftop PV generation in each location. The metrics and figures shown in the Rooftop PV and Solar Hot

Water Analysis subsections of Section 5 are relative to Package #1 of each scenario. Because the modeling scenarios all used the same prototype home, the available roof area was constant for each home, and therefore the size of the PV system was held constant. The roof area available for the PV system is 80% of the south facing roof for the entire duplex, which translated to a system size of 6.5 kWdc.

Due to the absence of snow data in the TMY3 weather data, we estimated losses due to snow cover with annual loss factors (Ryberg and Freeman 2017). Appendix A of *Integration, Validation, and Application of a PV Snow Coverage Model in SAM* provides loss factors for locations in the United States. at two different pitches. We apply the loss factors for a 20° tilt, which is closest to the roof pitch of the homes (26.6°). To determine the representative location that most closely aligns with the modeled locations, the annual snow fall, climate zone, and average temperatures were considered. The loss factors for snow cover help more accurately represent the annual PV generation of a location but do not account for seasonal effects. Therefore, results for the summer PV generation may be underestimated, while results for winter PV generation may be overestimated in locations with considerable snow.

Like the PV generation analysis, we estimate potential for solar hot water applied to upgrade Package #1. BEopt enabled simulation of solar hot water to estimate the utility cost savings and annualized costs. Each simulation assumed a 40ft^2 solar array per unit that pre-heats water to reduce the energy demand of the existing water heating system. The expected site energy savings, utility cost savings, and annualized energy cost savings were reported in each scenario.

B.3 Building Resilience Potential

As a preliminary step to understanding short-term energy resilience of the EE packages, we performed additional simulations of two packages, one subject to heat wave conditions in Arizona, and another during a polar vortex in the Minnesota. The methodology of the resilience study is as follows:

1. Identify locations and times of recent extreme weather events experienced in our set of locations (June 2017 in Sells, AZ and January 2019 in Bemidji, MN).
2. Pull the actual meteorological year (AMY) weather data for the given years and locations.
3. Export the baseline and cost-optimal designs into a ResStock input file.
4. Simulate the baseline and high-efficiency models with the AMY without a power outage.
5. Simulate the baseline and high-efficiency models with the AMY under simulated power outages of 12 hours, 24 hours, and 5 days.
6. Compare results to understand benefits to energy usage and indoor temperature.

The building designs outputted in BEopt were ported to a custom version of ResStock v2.5.0 to simulate the outages. In general, the building designs and energy outputs aligned with the BEopt versions; however, garages were not included because of a limitation of ResStock for single-family attached homes. The metrics of interest for resilience include magnitude of unmet heating/cooling setpoints, HVAC energy during extreme temperature period, and HVAC energy to recover the indoor temperature following a power outage, all of which were compared to the IECC 2021 baseline building under the same conditions. Unmet degree-hours were calculated as the sum of the difference between the indoor temperature and the setpoint temperature during each hour of the outage. Although benefits are demonstrated in this study, the packages used are

not necessarily optimized for energy resilience, and further benefits may be realized through more strategic measures, such as increasing thermal mass, more aggressive envelope efficiency upgrades, and ensuring tank storage for water heating.

Appendix C. Additional Resources

C.1 Installing Energy Efficiency Measures

This report recommends various measures for improving the energy performance of a new construction home, however, the detailed methods of installing such measures are not described. Below are three resources that may assist in the design and implementation of energy efficiency measures in order to compliment the recommendations in this guide.

- **Standard Work Specifications (SWS) tool**: https://sws.nrel.gov/
  Maintained by NREL, the SWS tool is a quick reference guide which details methods for high-quality and safe installation of energy efficiency measures, as agreed upon by industry professionals.

- **Building America Solution Center:** https://basc.pnnl.gov/
  The Department of Energy's Building America program publishes detailed guides to installing energy efficiency measures, generally as it applies to specific scenarios and components of a home.

- **Energy Saver Program:** https://energy.gov/energysaver/energy-saver
  The Department of Energy's Energy Saver program provides high-level information about energy efficiency measures. This information includes introduction of technologies, commercially available options, and suggestions on how to optimize the technology's energy performance.

C.2 Solar PV Analysis

Our rooftop solar potential results represent a first step towards understanding the benefit of a solar energy system when combined with an energy-efficient building design. To appropriately understand the site-specific technical potential and economic benefits, a more detailed study should be performed. Details that influence PV potential and may vary from our assumptions include shading, roof pitch, building orientation, available roof area, and buy and sell rates for electricity. There are numerous commercially available tools to help estimate solar energy potential. Our specific analysis relied on the PVWatts module built into the SAM software, but more information on all the relevant DOE tools can be found at: https://www.energy.gov/eere/solar/solar-rooftop-potential.

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