



U.S. DEPARTMENT OF ENERGY

Solar Decathlon

Building the
Next Generation

August 2023
American Solar Energy Society Conference
Boulder, CO



Local Residential Builds with National Impact

Jes Brossman National Renewable Energy Laboratory
Paul Neumann University of Colorado Boulder
Emmanuel Iddio University of Wyoming



Solar Decathlon Impact

21 Years of Excellence



WORKFORCE
DEVELOPMENT



INNOVATION



MARKET
TRANSFORMATION

“Over the last two years of Solar Decathlon I was able to find a true passion and am forever grateful for it. It has made a profound impact on my life; I am so happy for everything I have learned and could have never imagined all the connections we would make.”

“I aspire to use my learnings from Solar Decathlon to make a safe and sustainable built environment that makes our community more resilient to extreme climate events. SD is a great place of learning to find innovative ways to contribute to the community by promoting sustainable lifestyles.”

- 2023 Build Challenge Students

Then: Solar Decathlon 2002...



COMPETITION MODEL

8 editions of a public showcase model held from 2002 to 2017.



PROGRAM OBJECTIVES

Create proving ground for residential solar and energy efficiency, while training future workforce.



REACH

Collegiate-level students only, with focus on traditional 4-year schools and programs.



EVENTS

Large, multi-week, public-facing temporary exhibits held at centralized locations, such as the National Mall.



...and Now: Evolution to 2023

COMPETITION MODEL

First **all-local build model** implemented for **2023 Build Challenge**, complementing ninth edition of design-only **2023 Design Challenge**.

PROGRAM OBJECTIVES

Provide a proving ground for residential solar and energy efficiency, while **training future workforce** to tackle **environmental justice** and the **climate impact** of **existing** residential and commercial buildings.

REACH

Collegiate-level students ~~only~~

SD Build **SD Design**

+

Industry Professionals

SD Pro

+

High School

SD Pathways

+

Local Communities

SD Communities

+

All Learners

SD Building Sci

EVENTS

Large, multi-week, public-facing temporary exhibits held at centralized locations, such as the National Mall.



Hybrid events for more equitable and accessible competition participation and global, public visibility.



2023 Build Challenge

Community Zero Energy Building Solutions

Build Challenge Successes

- Student competition and a technology demonstration platform
- Provides opportunity for showcasing and incubating emerging technologies
- Enables deep involvement with builders and manufacturers
- Emphasizes community engagement



Normalizing Zero Energy Construction

- **Transforming the market through contractor education and training the future workforce.**
 - Students are involved in all aspects of construction while leveraging local contractors, trades, unions, and industry partners.
 - Teams introduce innovative technologies to their local workforce in an approachable and meaningful way.
- **Bringing real and sustained impact to local communities.**
 - Many teams partnered with Habitat for Humanity or other local housing organizations to create affordable housing solutions.
 - Every team has a long-term plan for the building, from selling the home on the market, to a rent-to-own model for a low-income family, to a living laboratory for research.



University of Colorado Boulder



Team Name: Spruce Canopy
Build Location: Boulder, Colorado

The University of Colorado Boulder is building a highly efficiency and resilient 670 ft², carriage-style for an affordable housing community in north Boulder.



1st place in Durability and Resilience Contest
3rd place in Engineering Contest

University of Wyoming



Team Name: Wind River
Build Location: Fremont County, Wyoming

Using reclaimed wood from a 2020 wildfire, this 2,460 ft² home is an example of sustainable, single-family housing in rural Wyoming.



- 1st place (tie) in Occupant Experience**
- 1st place in Comfort and Environmental Quality**
- 1st place (tie) in Energy Performance**
- 3rd place in Embodied Environmental Impact**



Steward Sponsorship Level

LEGENCE



Supporting Sponsorship Level



Contributing Sponsorship Level





U.S. DEPARTMENT OF ENERGY

Solar Decathlon

Building the
Next Generation

Thank you

Catch us all at the Students On Sustainability :
Young Professionals Program on Friday

Poster on Solar Decathlon Design Challenge

Jes Brossman, jes.brossman@nrel.gov

The Canopy

Energy Independence On The Front Range



Solar Decathlon
UNIVERSITY OF COLORADO BOULDER
STUDENT ORGANIZATIONS



U.S. DEPARTMENT OF ENERGY

Solar Decathlon

Project Intro - CU Solar Decathlon

- Approximately 20 engineering and environmental design students
- Project began with Flatirons Habitat For Humanity & City of Boulder on Ponderosa Stabilization Plan



Goals

Improvement & Low-Impact to:



Occupant



Community



Environment

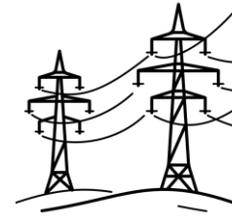
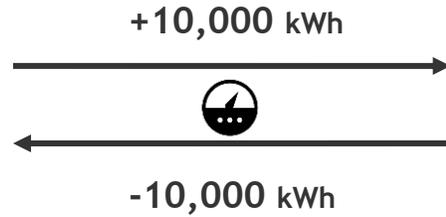
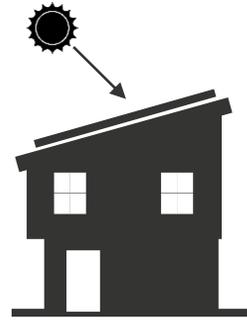


Grid Interaction

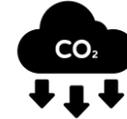


Moving Past Net-Zero Energy

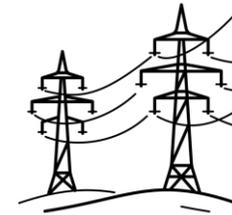
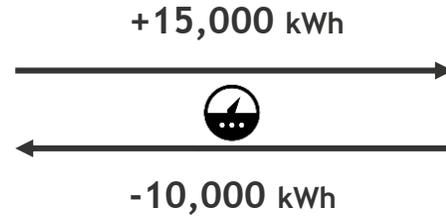
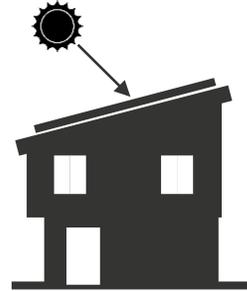
Net Zero Home



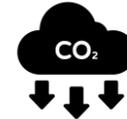
Reduce



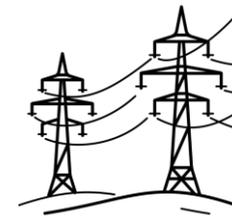
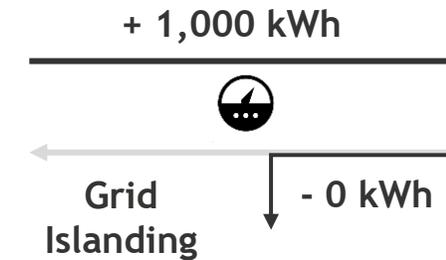
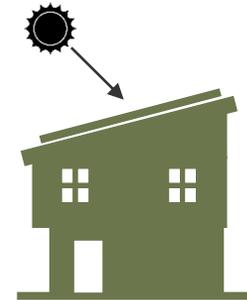
Net Positive Home



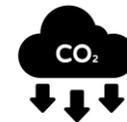
Support Electrification



Energy Independent



Grid Friendly, Resilient, Independent



Diversified Energy Storage

To Build an Energy Independent Home...

1. High Performance & Air-Tight Envelope
2. A Way To Manage & Control Loads
3. Excess Renewable Generation
4. Flexible & Diversified Energy Storage

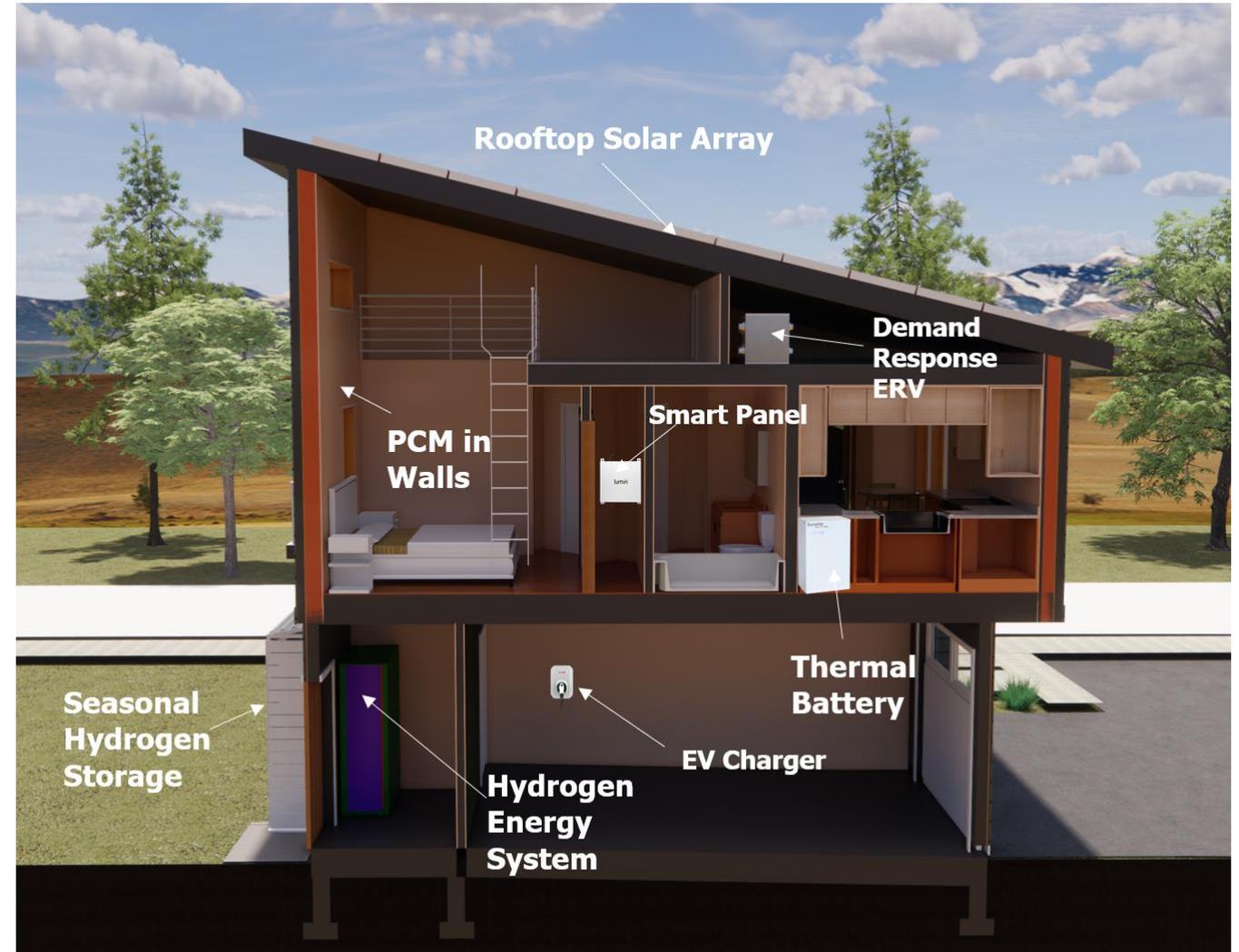
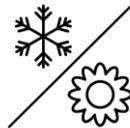
Electrical



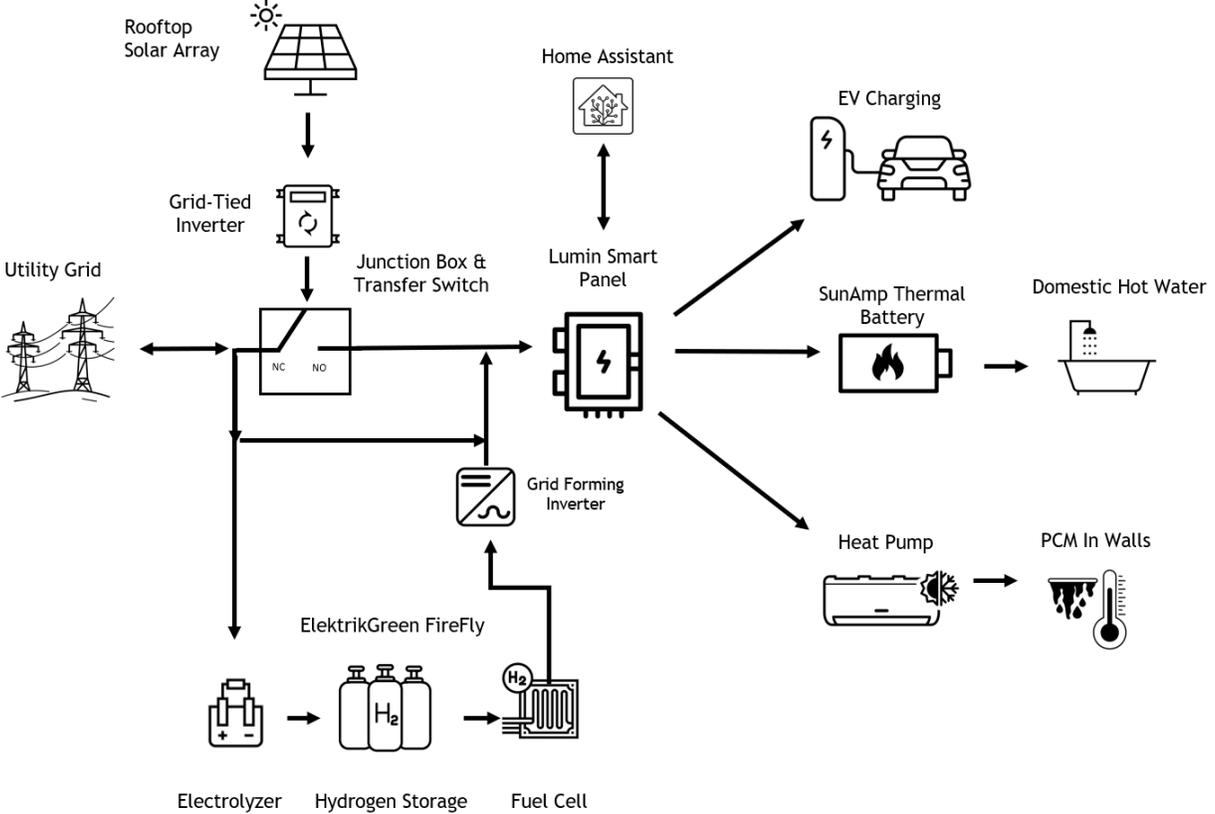
Thermal



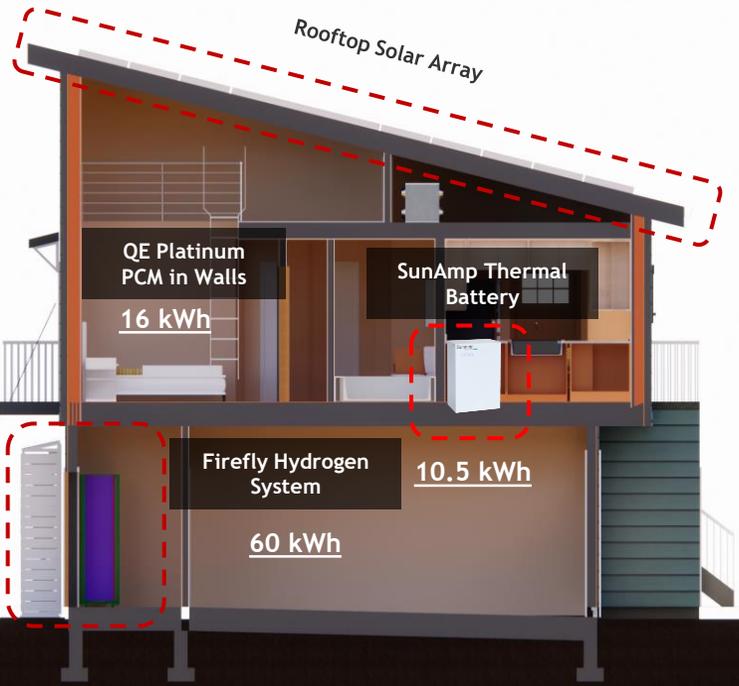
Seasonal



Flexible Energy



Winter
 Ave Daily Demand = 11.6 kWh
 Ave Nightly Demand = 6 kWh



Rooftop
Solar Array

Green Hydrogen

ElektrikGreen FireFly



Electrolyzer

Hydrogen Storage

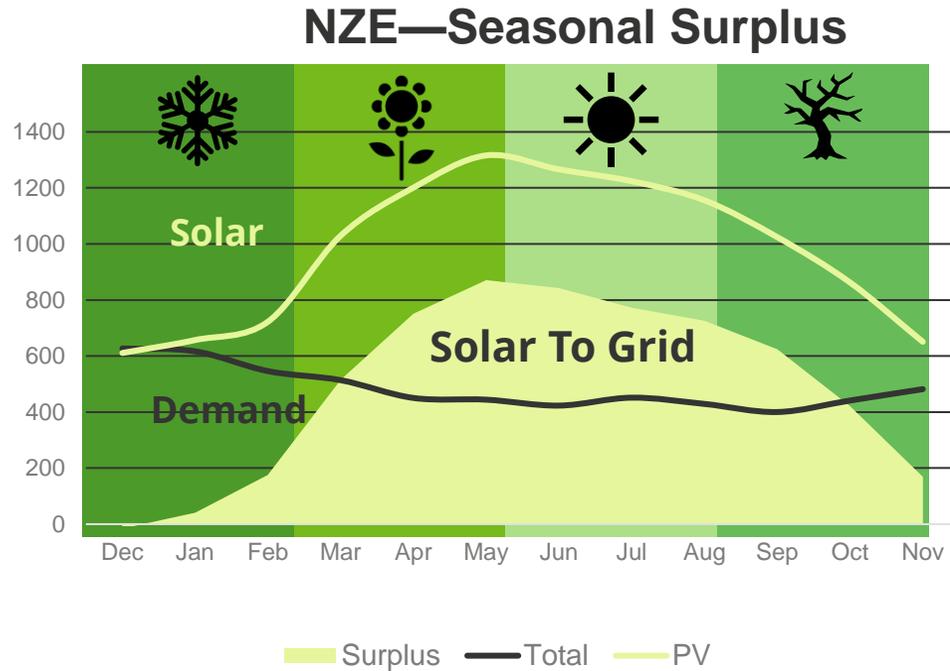
Fuel Cell



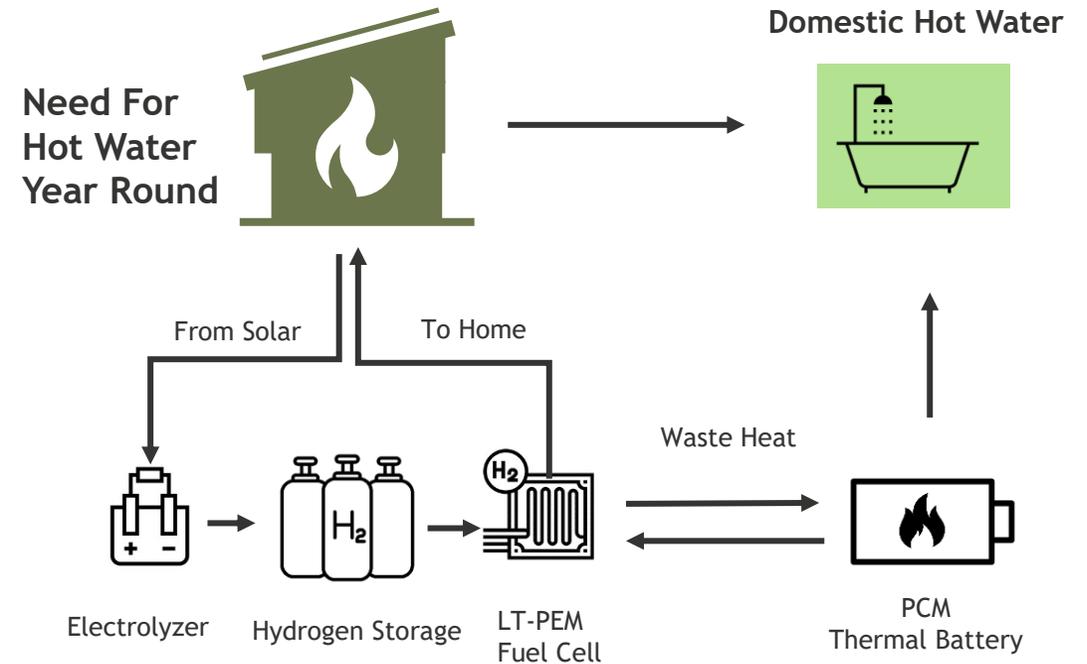
ElektrikGreen

Why H₂ ?

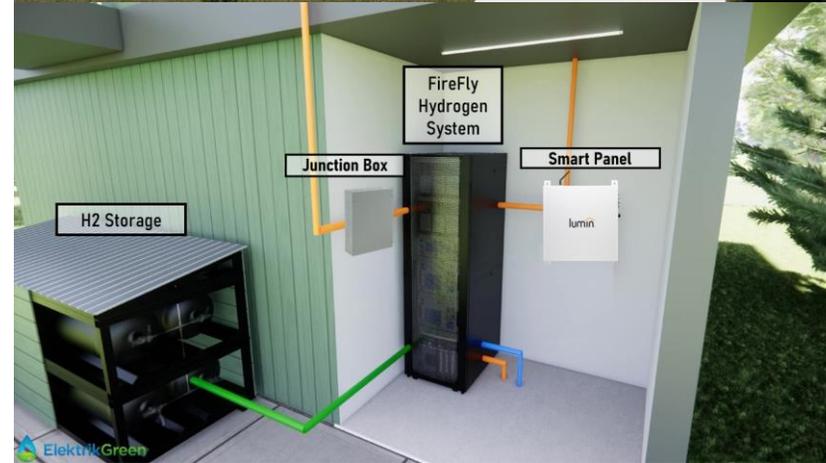
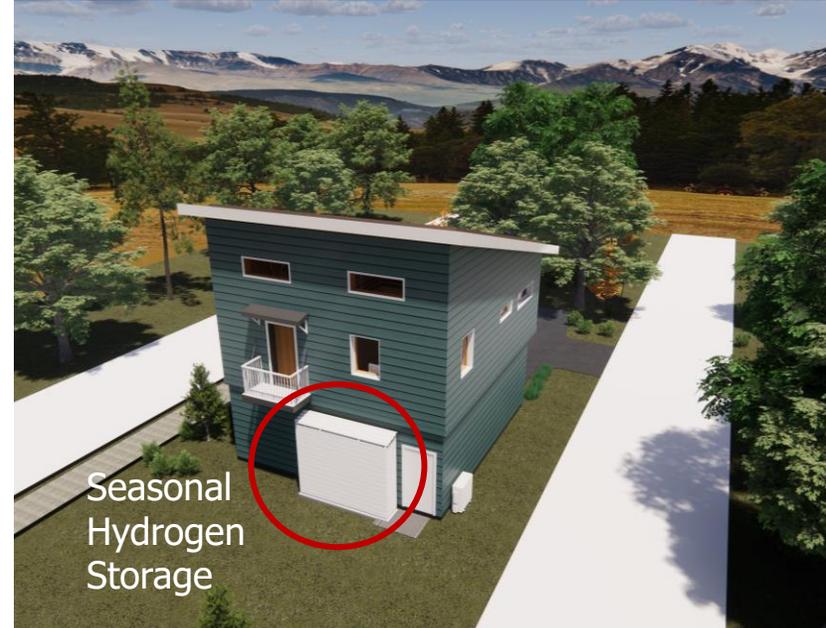
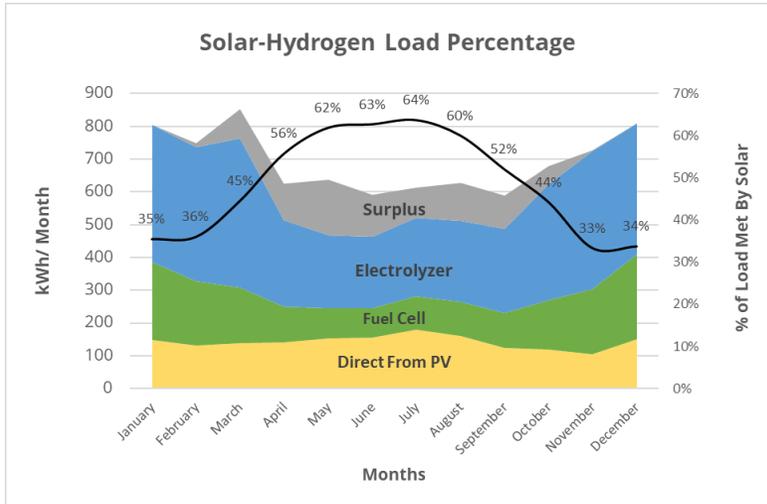
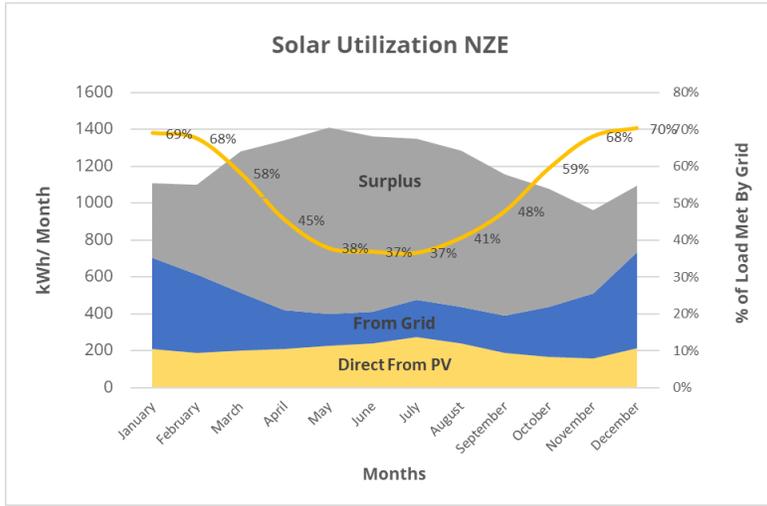
Seasonal Storage



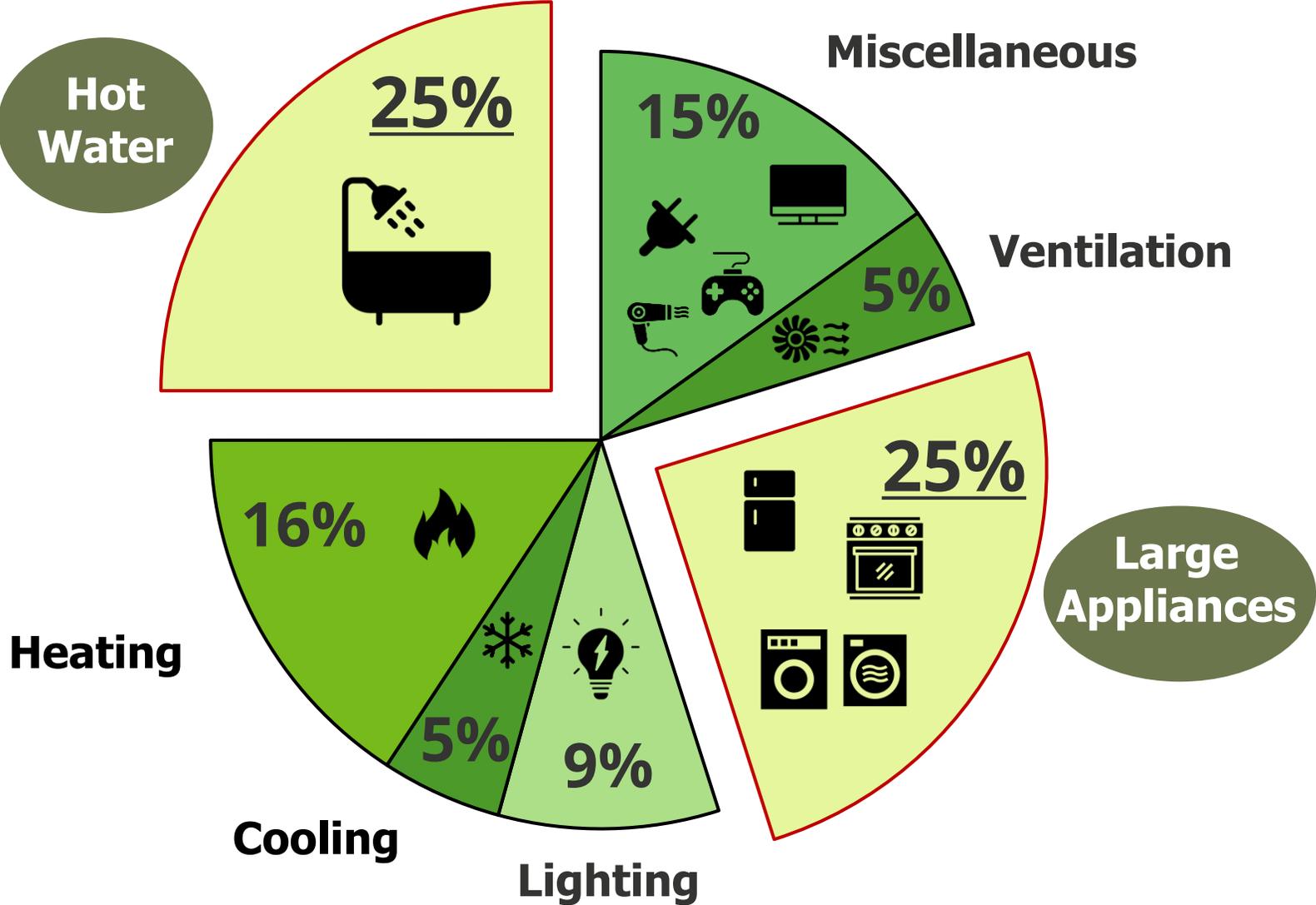
Opportunity For Waste-Heat



Seasonal Energy Storage



Share of Energy in High Performance Homes¹

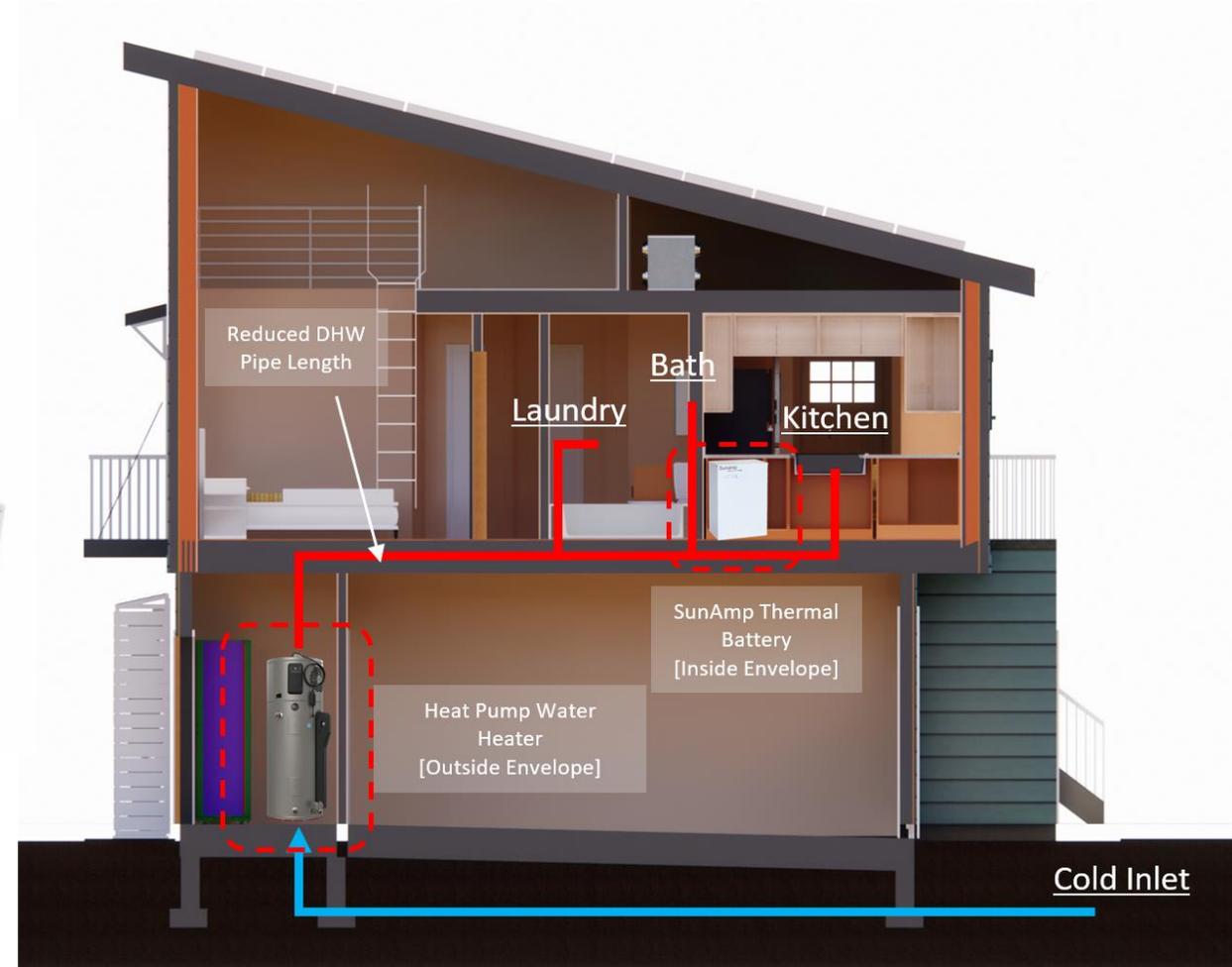
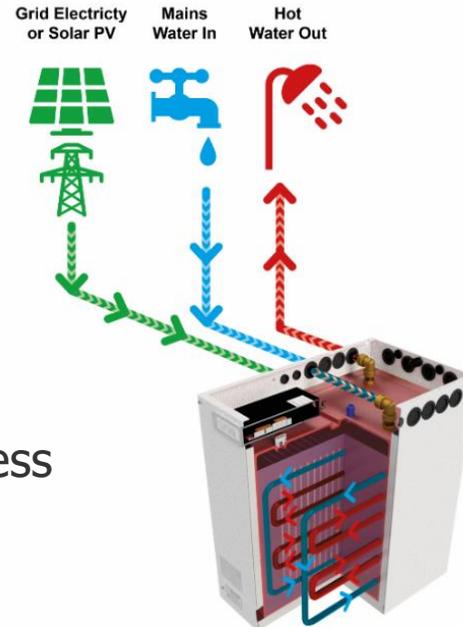


Thermal Storage



PCM Thermal Battery

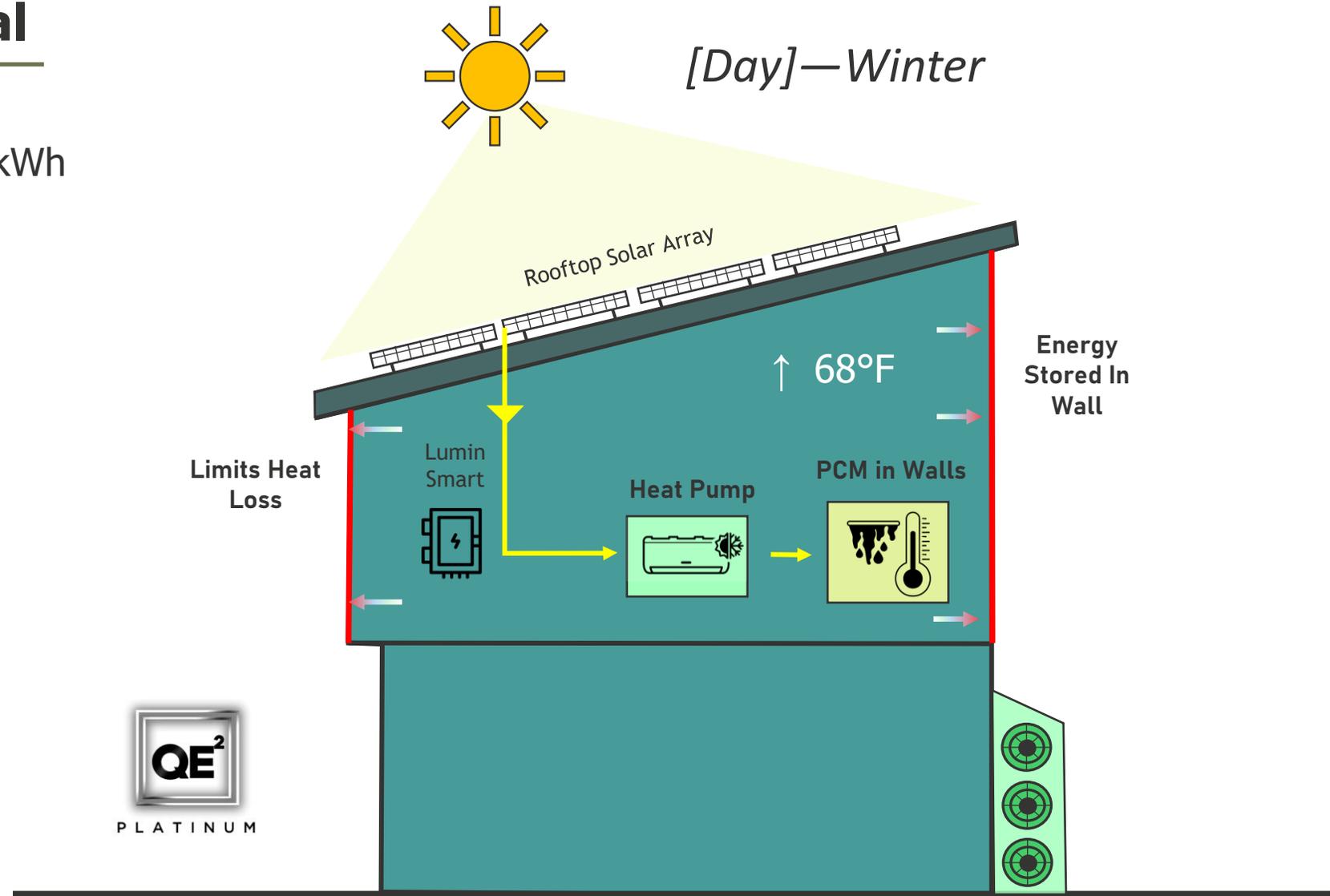
- Lower Cost than Electric Storage
- Sponge for excess energy storing Heat, rather than electricity
- Combines benefits of tankless and tanked water heaters
- Compact, inside envelope
- Adds Hot Water Resiliency



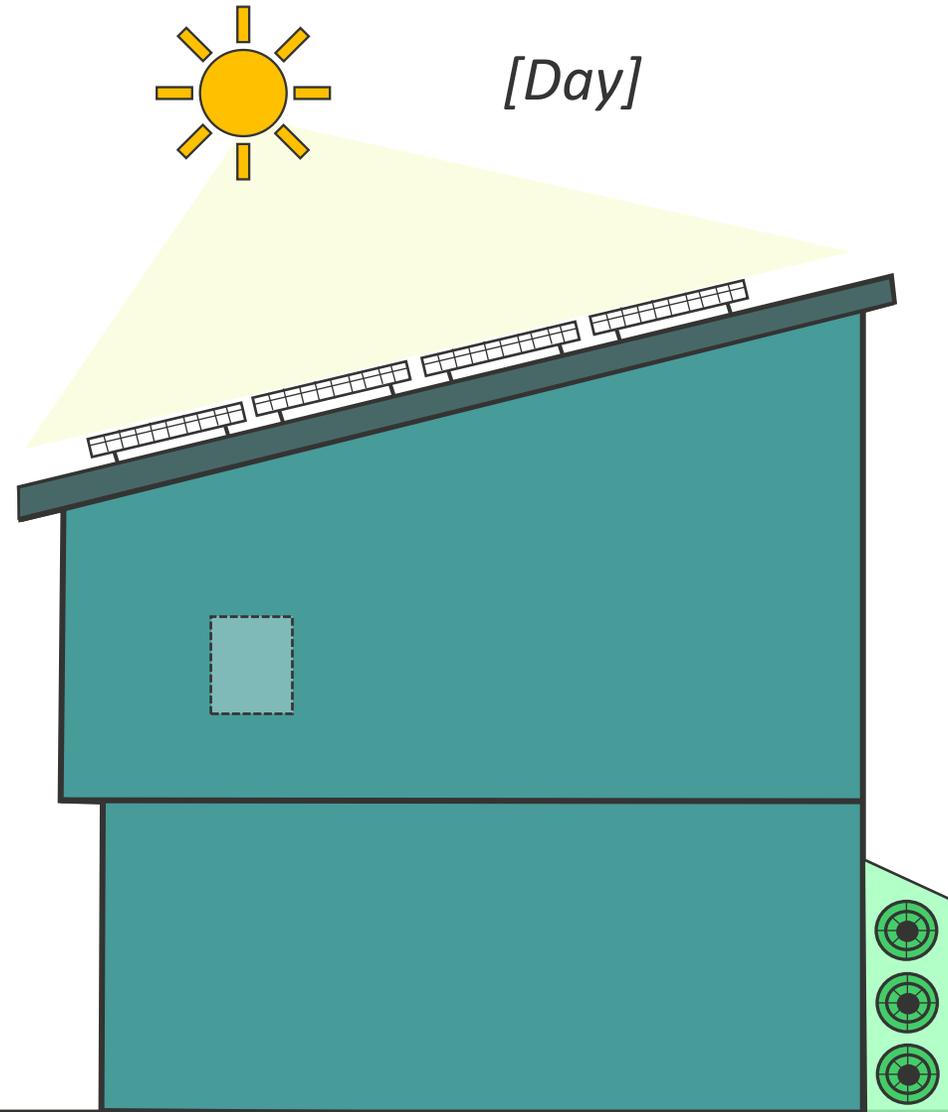
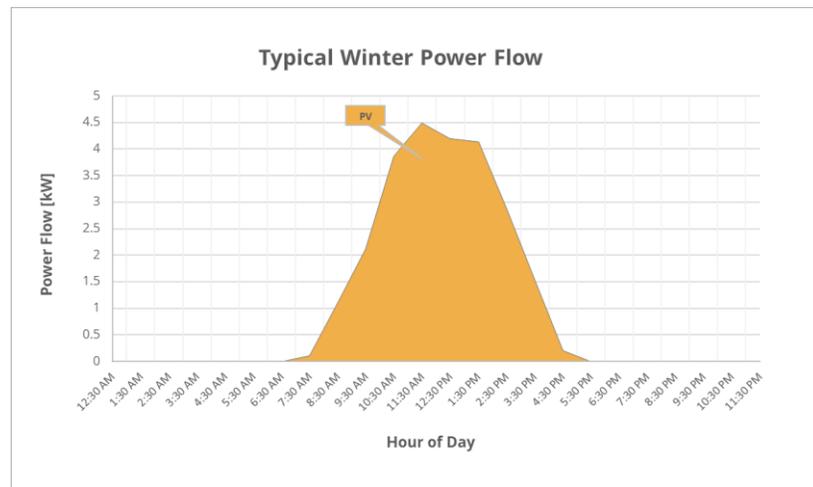
Phase Change Material

➡ 800 SF [PCM Sheets] = ~16kWh

➡ Intercepts & Stores Heat

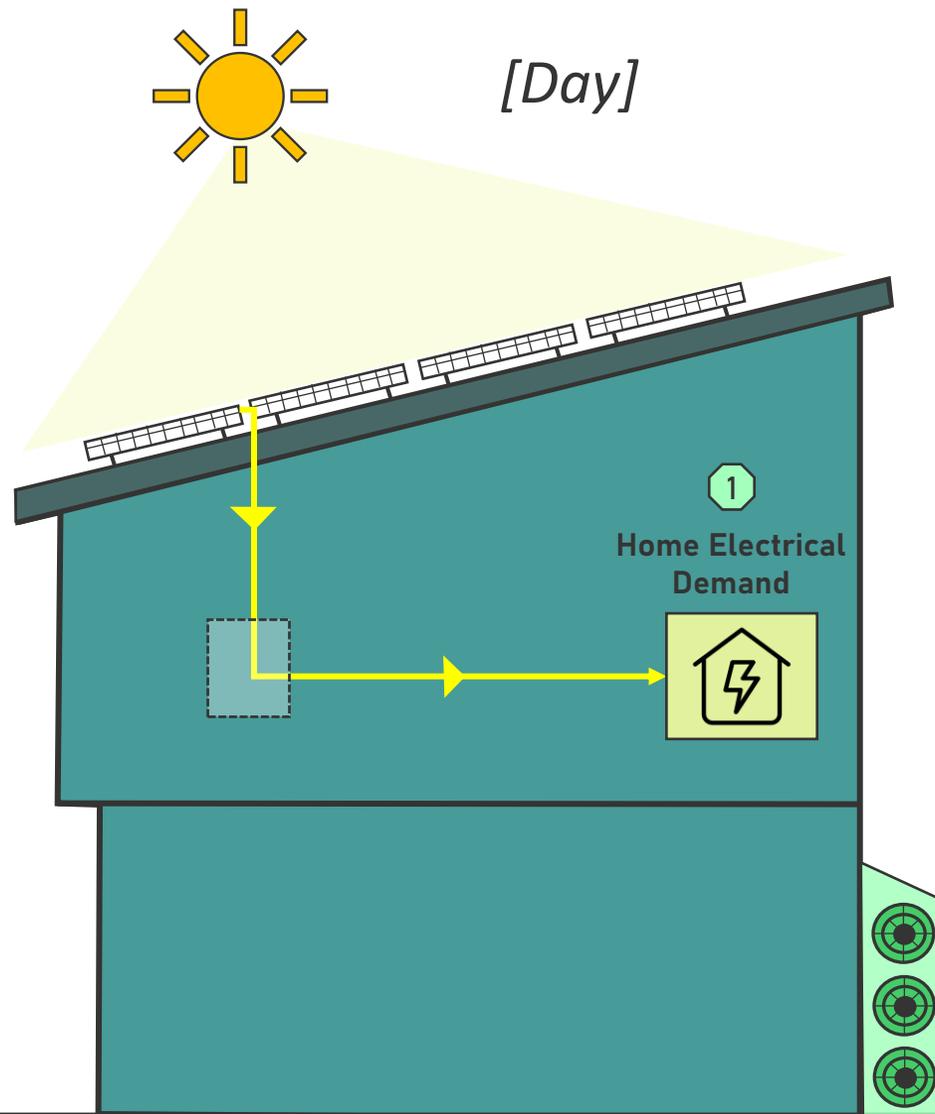
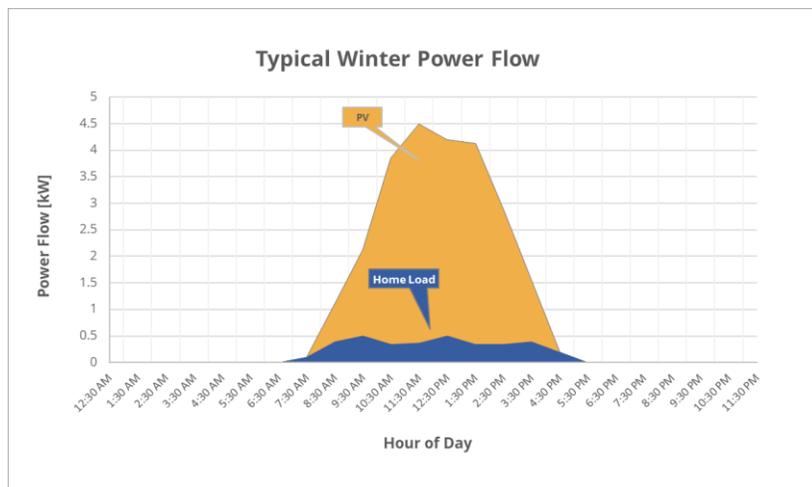


Energy Storage!



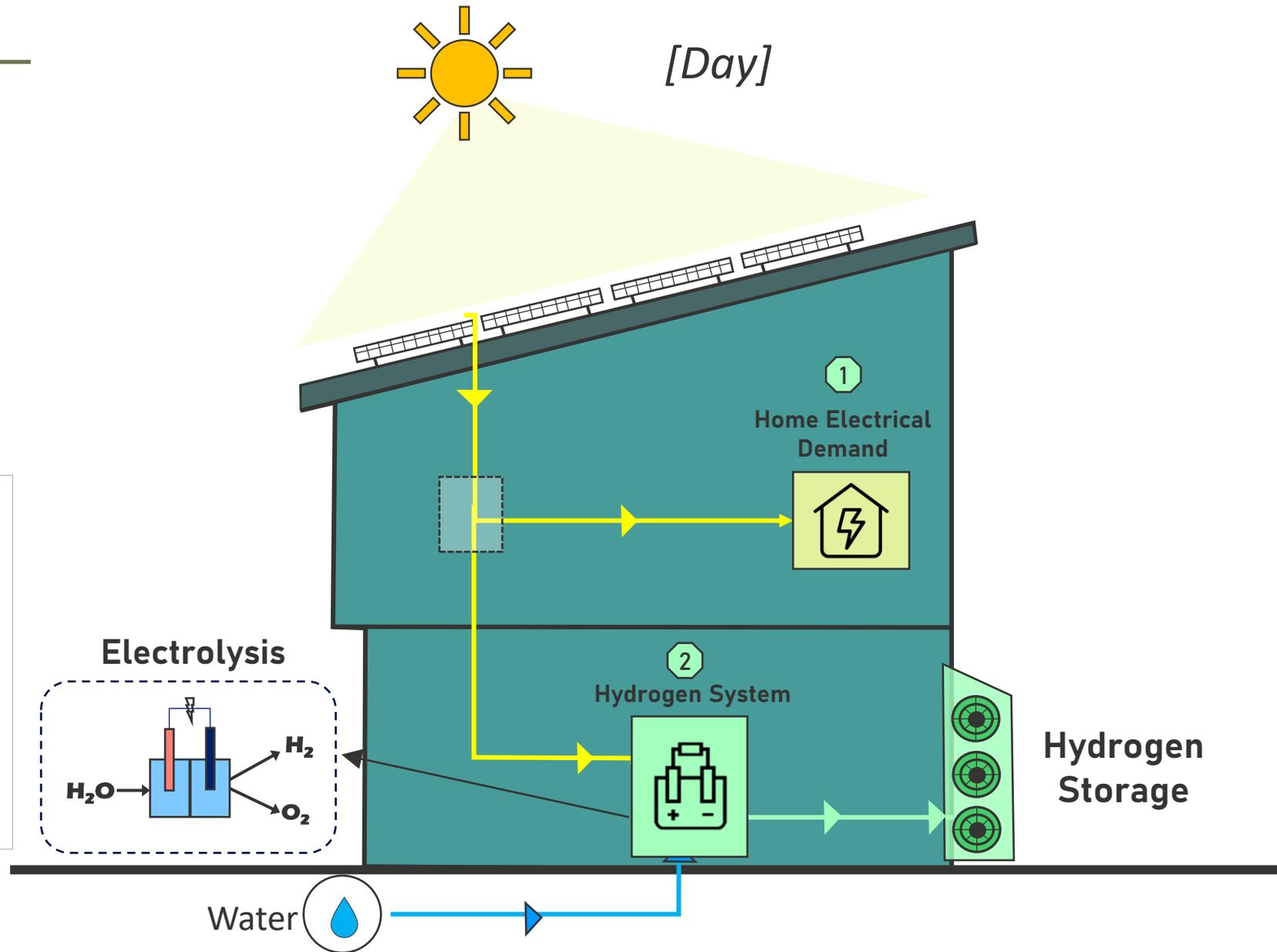
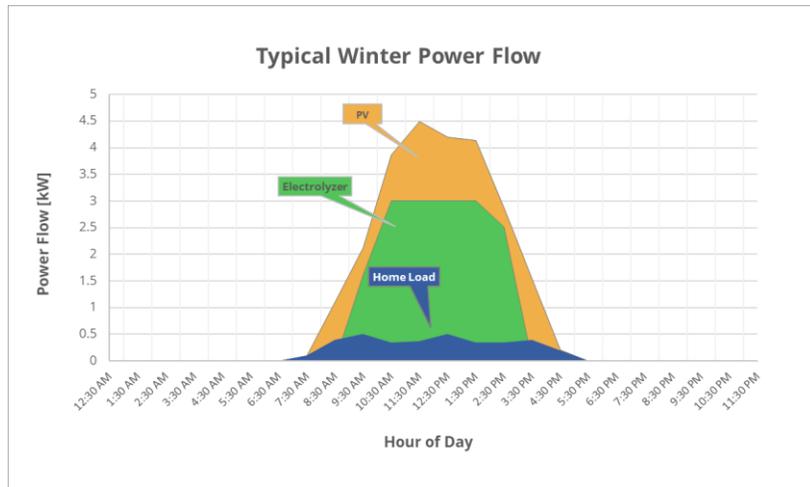
Energy Storage!

1 Direct-To-Home



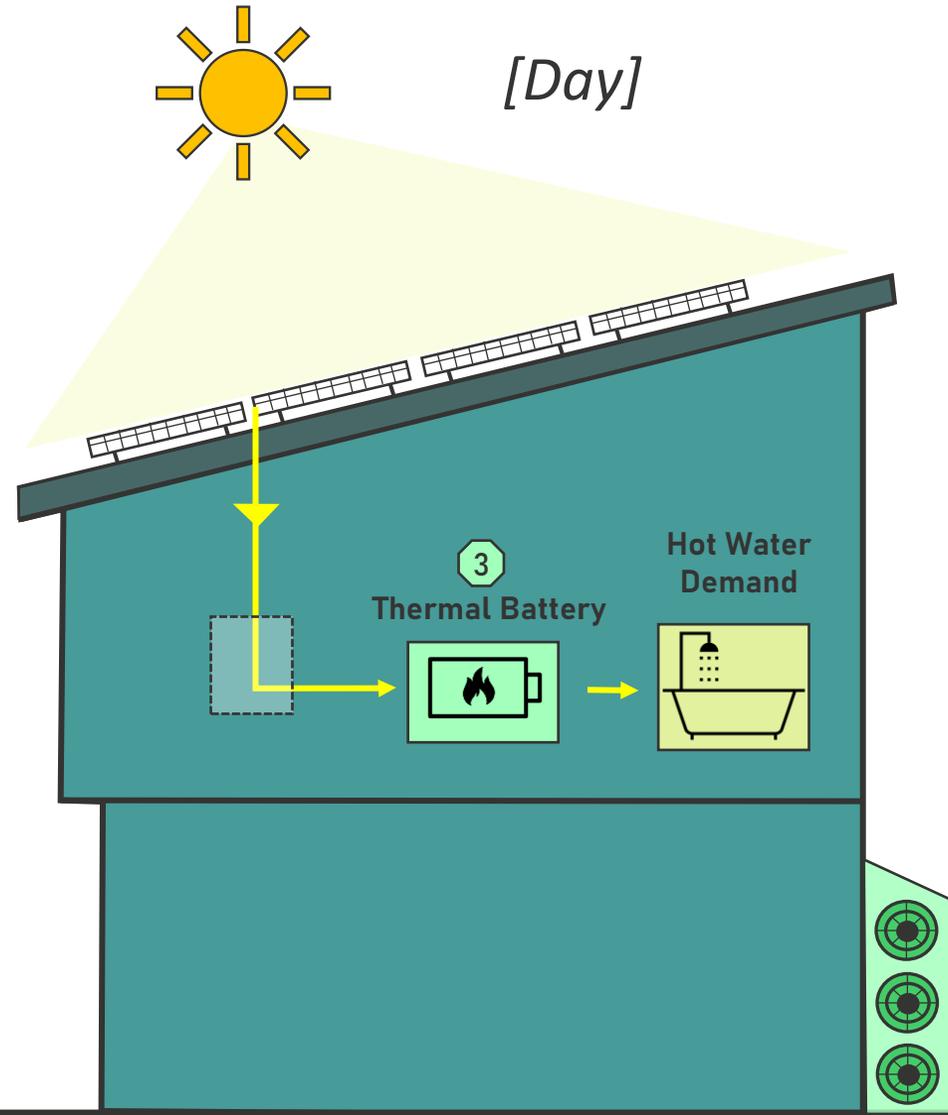
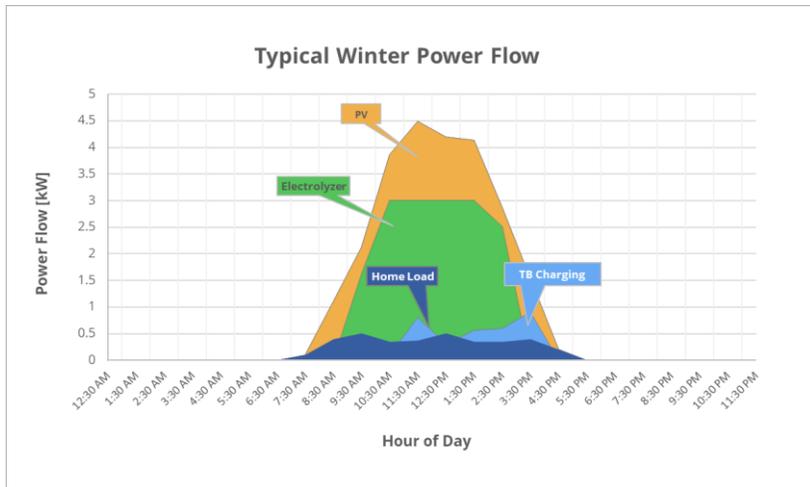
Energy Storage!

- 1 Direct-To-Home
- 2 Hydrogen Production



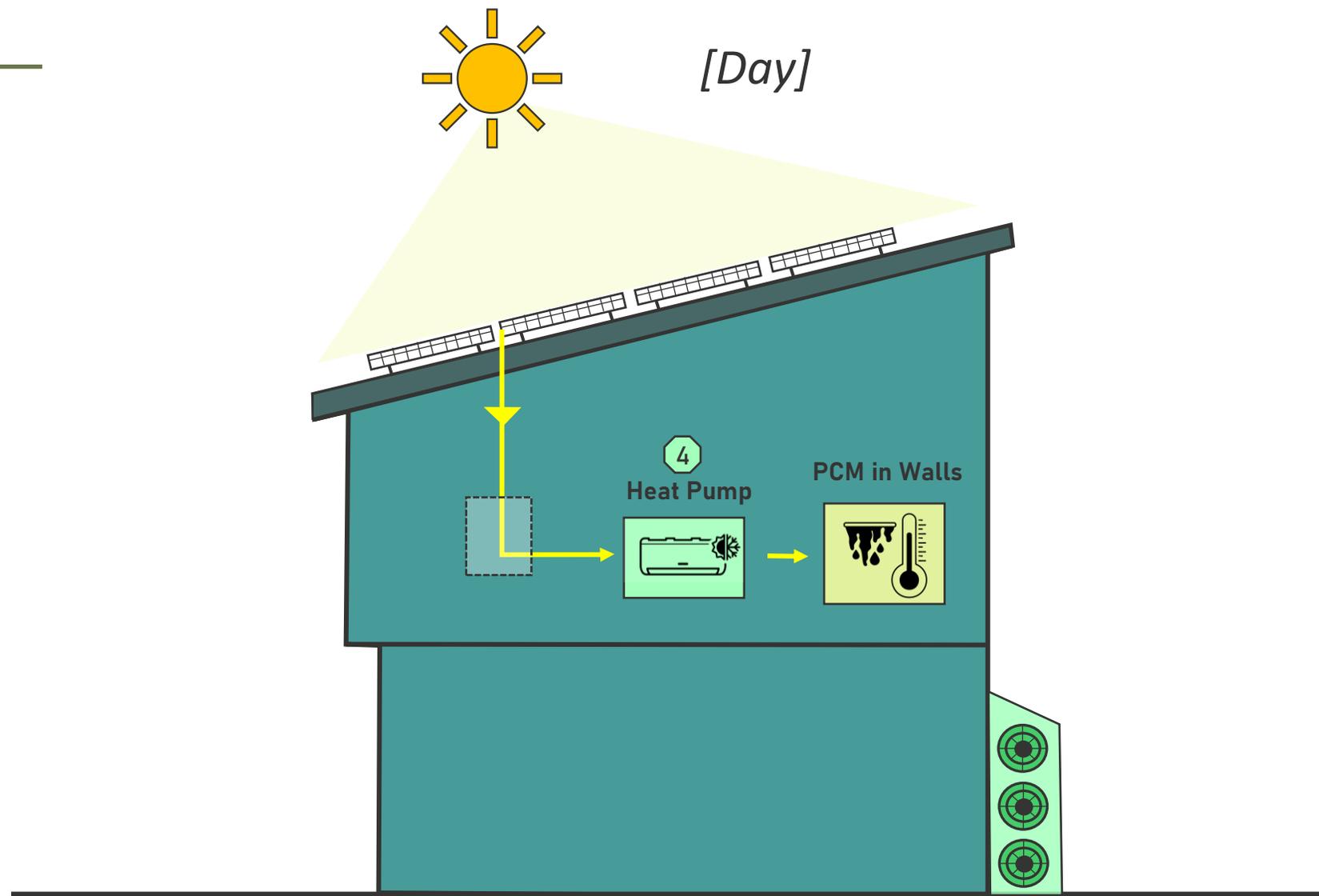
Energy Storage!

- 1 Direct-To-Home
- 2 Hydrogen Production
- 3 Thermal Battery



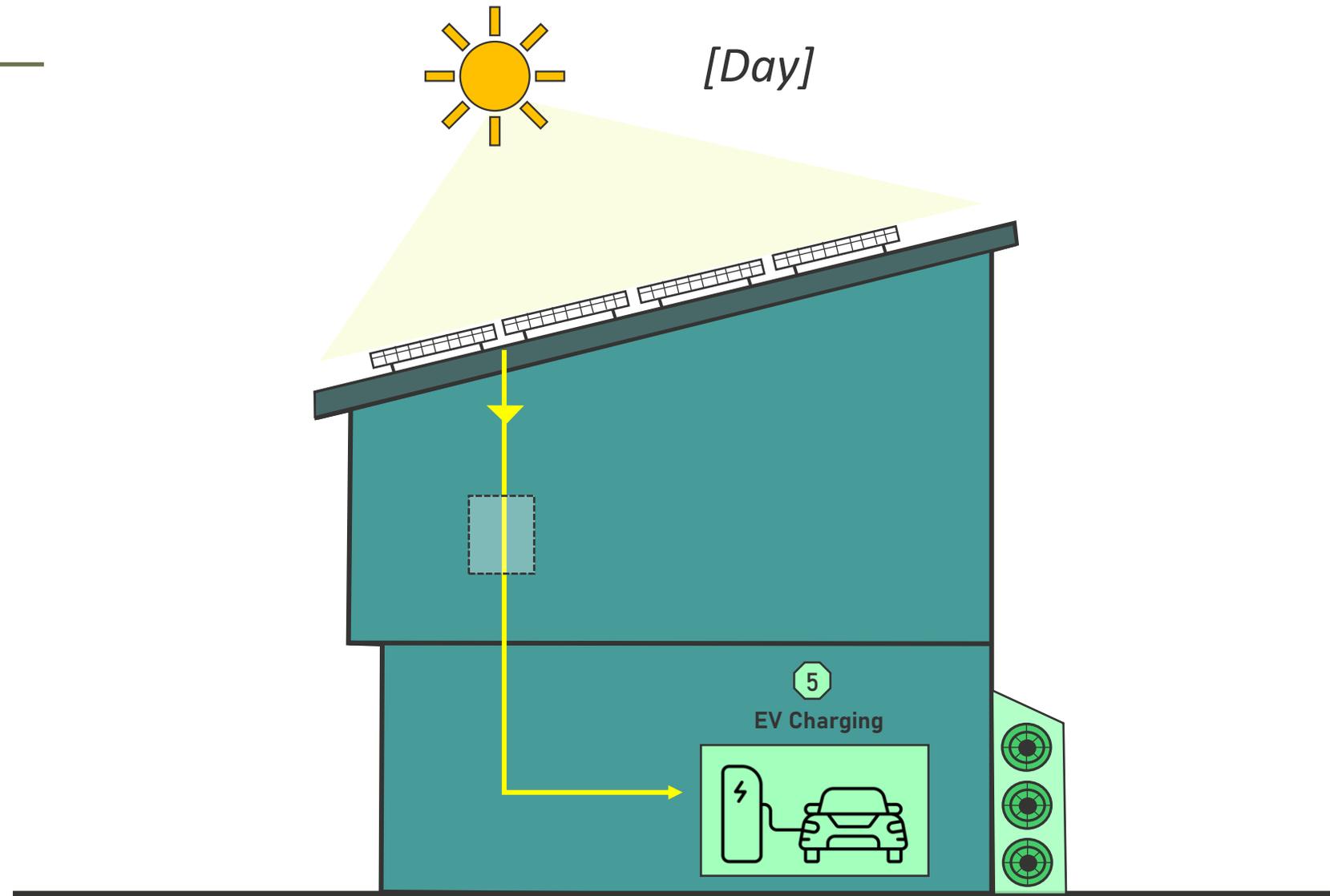
Energy Storage!

- 1 Direct-To-Home
- 2 Hydrogen Production
- 3 Thermal Battery
- 4 PCM in Walls



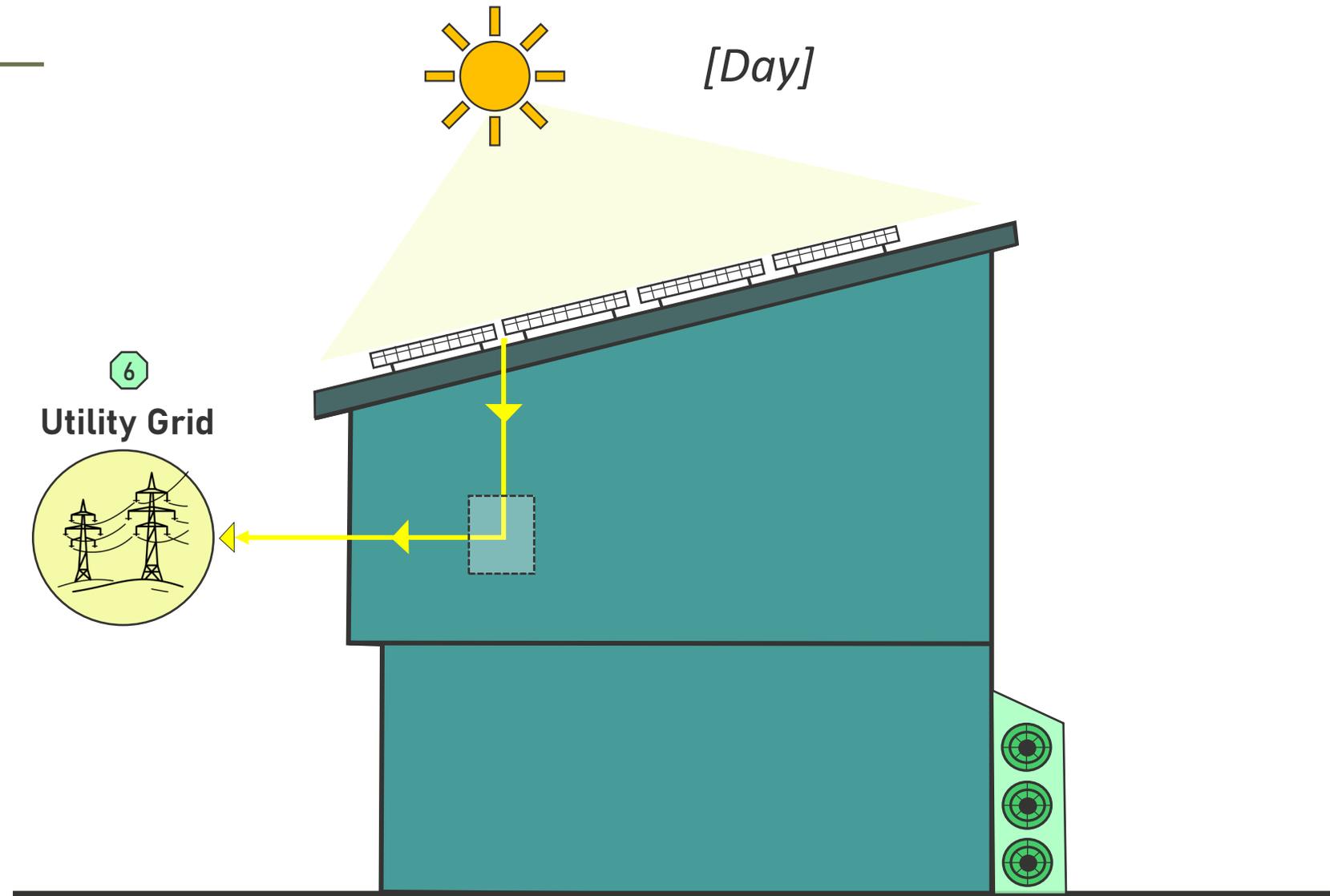
Energy Storage!

- 1 Direct-To-Home
- 2 Hydrogen Production
- 3 Thermal Battery
- 4 PCM in Walls
- 5 EV Charging



Energy Storage!

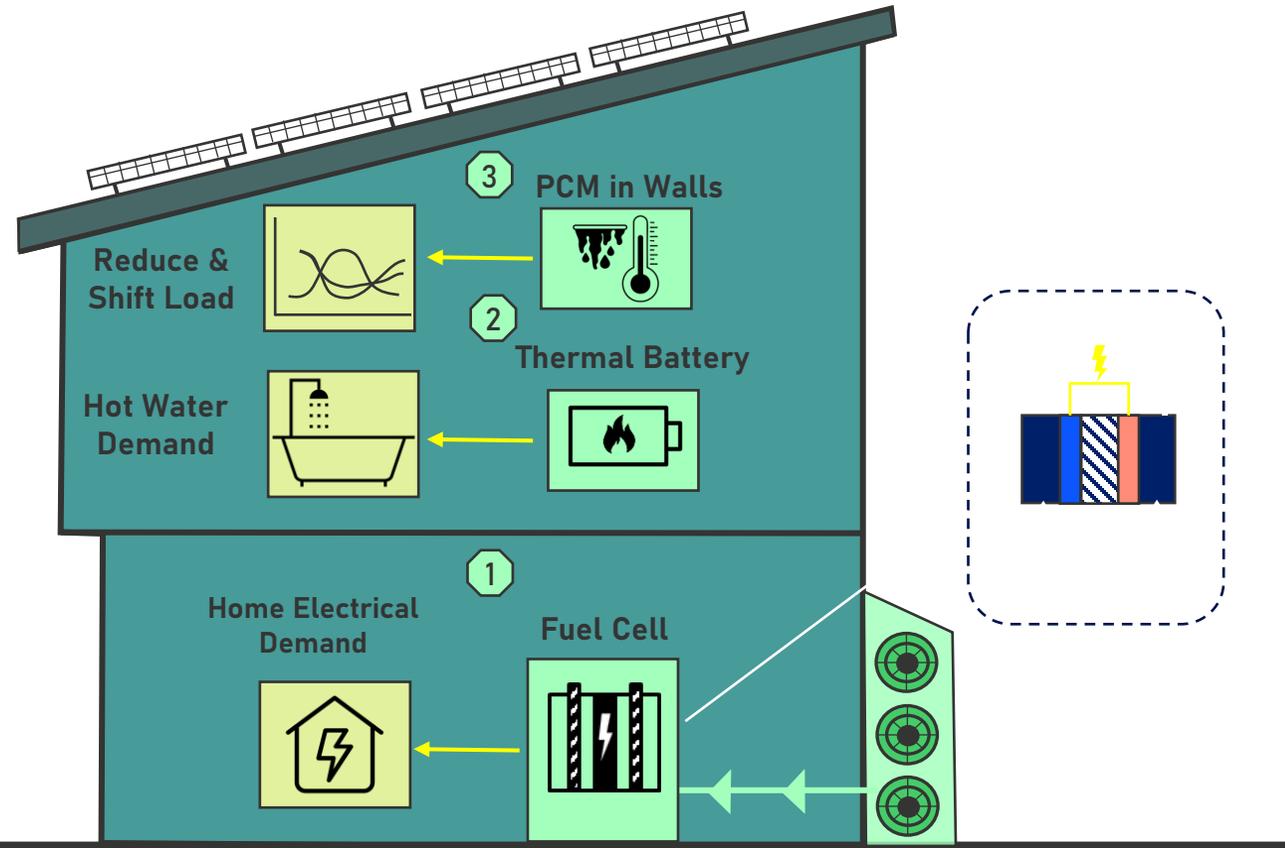
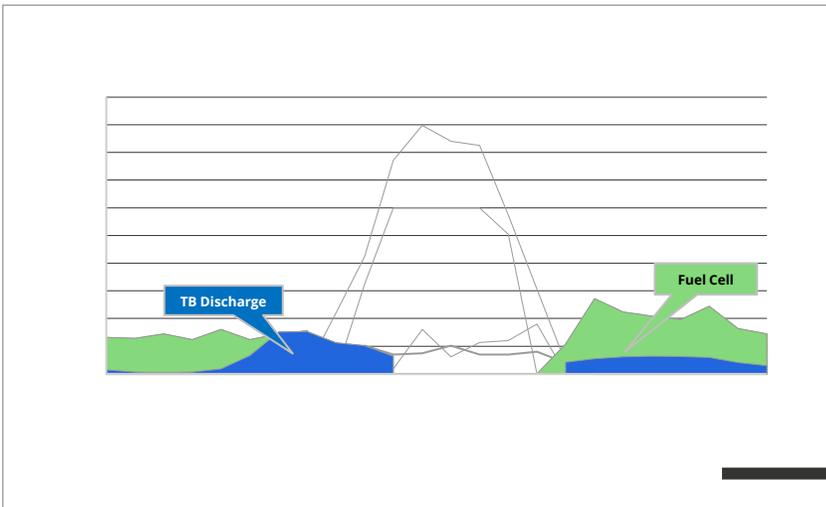
- 1 Direct-To-Home
- 2 Hydrogen Production
- 3 Thermal Battery
- 4 PCM in Walls
- 5 EV Charging
- 6 To Utility Grid



1

2

3





ElektrikGreen



GLENN FRANK ENGINEERING, INC.



Thank you!



Follow Our Journey!

<https://www.cubouldersolardecathlon.com>

Contact: Paul.Neumann@colorado.edu

University of Wyoming

UWYO
WIND RIVER



WIND RIVER
WYOMING







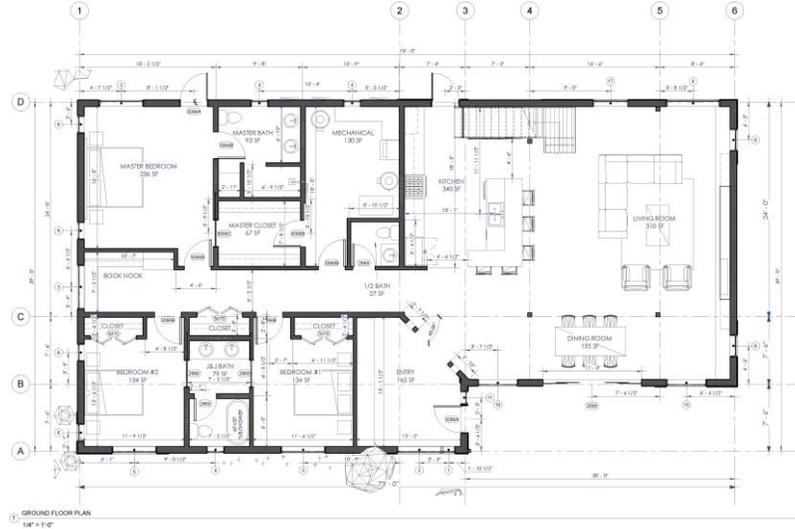
Pre-Design Approach

- ‘Spec’ home: Builder as client
- Market-ready design
 - Typical 3-BR 2.5-BA program
 - “Minimal Mountain Modern” style
- Emphasis on Constructability
 - Standard wood framing
 - Off-the-shelf equipment
- Site and Climate
 - Cold climate (Zone 6B- Dry)
 - Very good solar resource
 - Supports Passive and Active solar



Cory Toye (UW Alumni)
Client | Builder

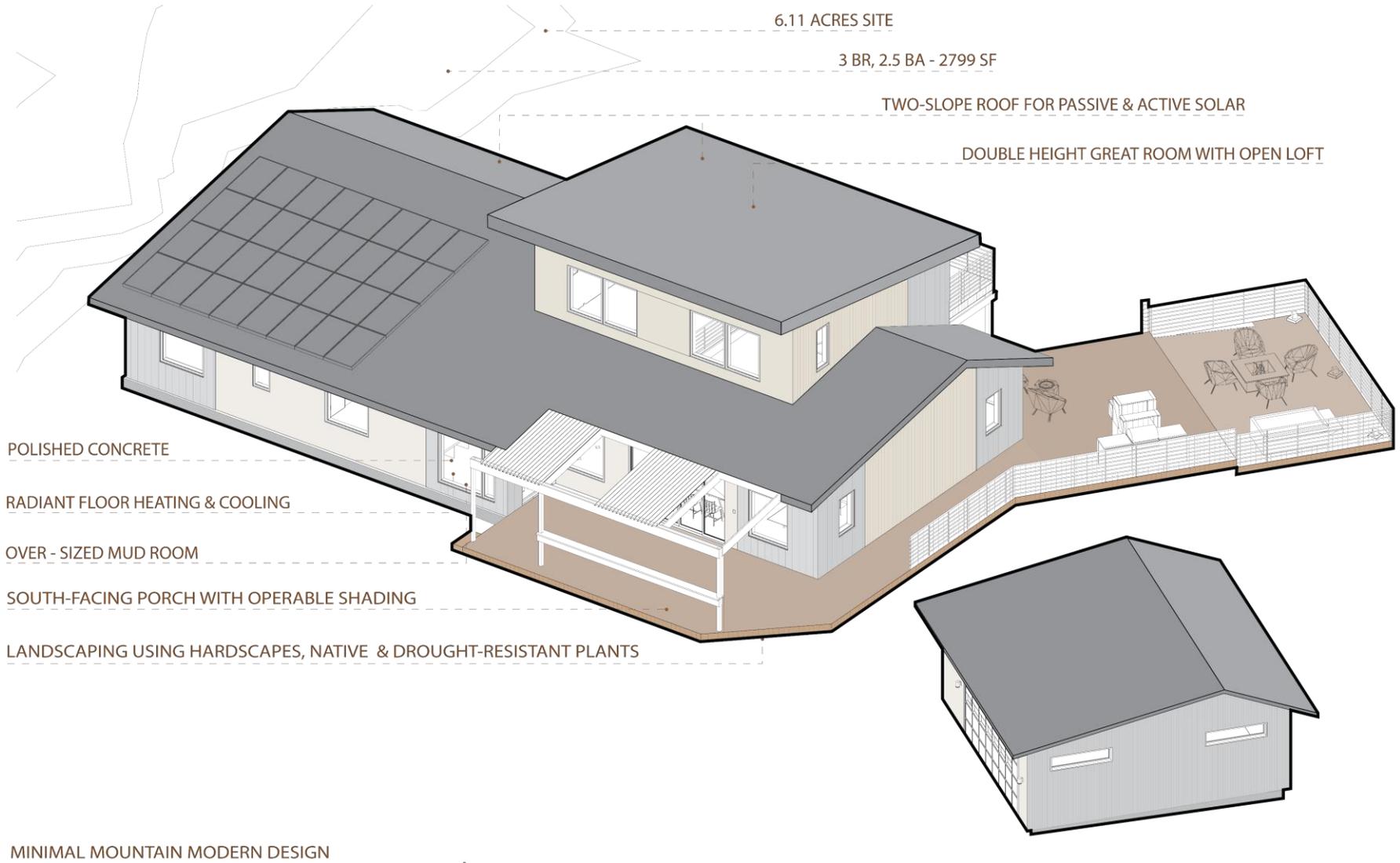
Design Process



1 Spring | 2021
10 students

2 Between 2021–2022
9 students; all new

3 Between 2022–2023
10 students; 7 new



6.11 ACRES SITE

3 BR, 2.5 BA - 2799 SF

TWO-SLOPE ROOF FOR PASSIVE & ACTIVE SOLAR

DOUBLE HEIGHT GREAT ROOM WITH OPEN LOFT

POLISHED CONCRETE

RADIANT FLOOR HEATING & COOLING

OVER - SIZED MUD ROOM

SOUTH-FACING PORCH WITH OPERABLE SHADING

LANDSCAPING USING HARDSCAPES, NATIVE & DROUGHT-RESISTANT PLANTS

MINIMAL MOUNTAIN MODERN DESIGN

Form: Roofs



South slope: For PV

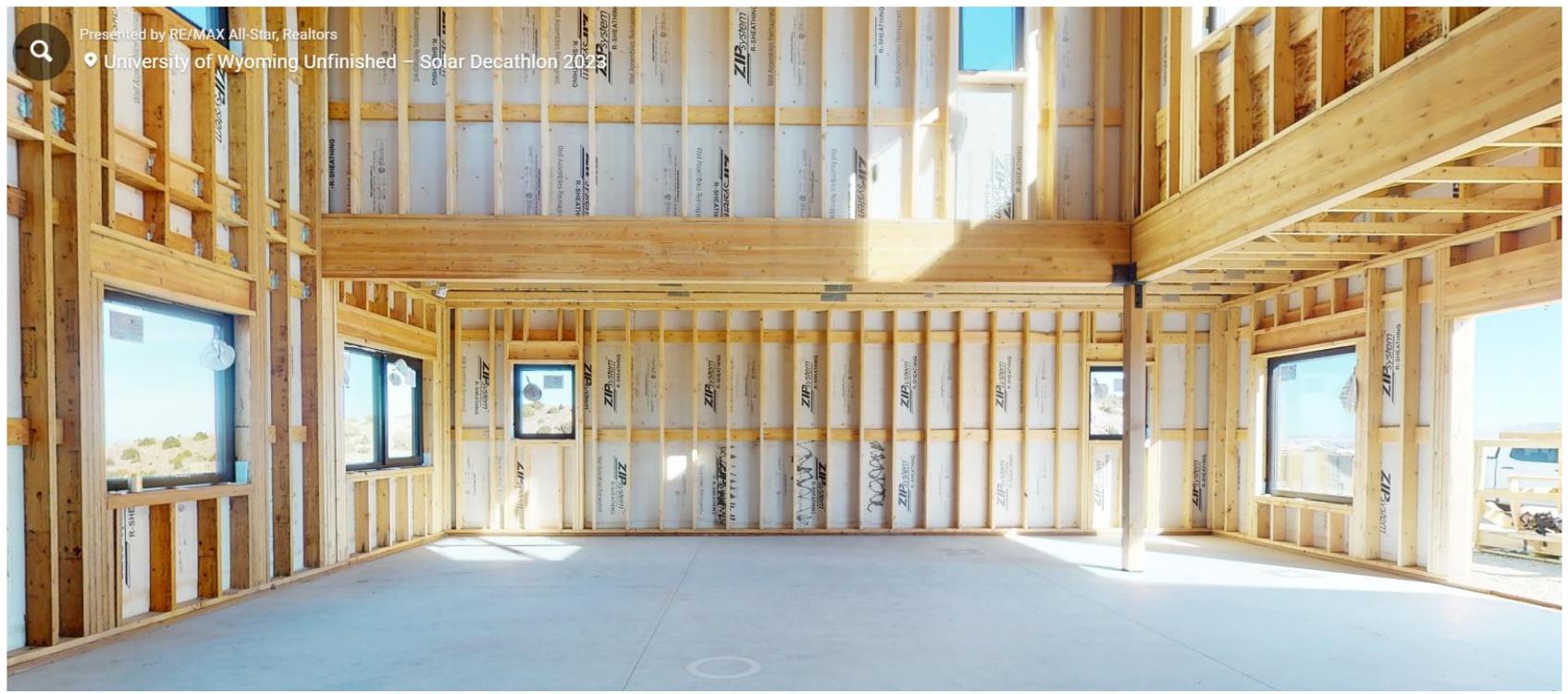


North slope: creates tall south wall for passive

Double-height and Loft Spaces

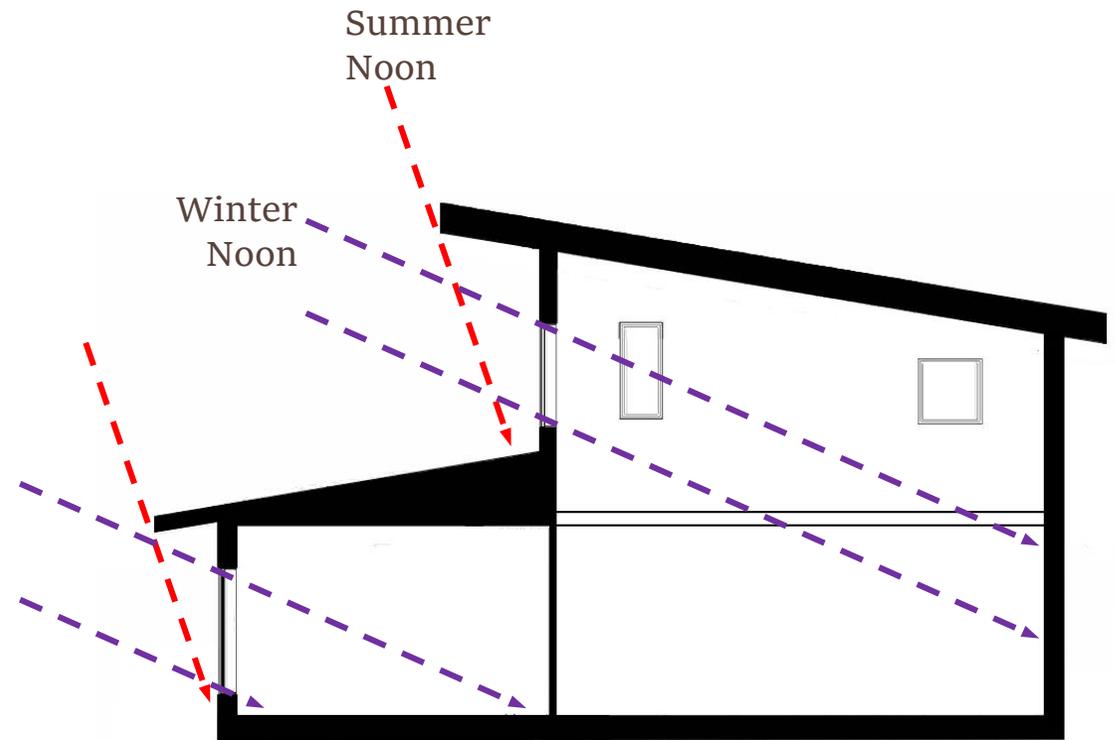


Form: Passive Solar and Shading



Natural lighting and passive heating

Form: Passive Solar and Shadin



House rotated 15 degrees Southeast to optimize solar gain



0.25 ACH – Tightest Envelope in WY!

$T_{\text{indoor_avg.}} = 64^{\circ}\text{F}$ @ $T_{\text{outdoor_avg.}} = 27^{\circ}\text{F}$ with no active heating!

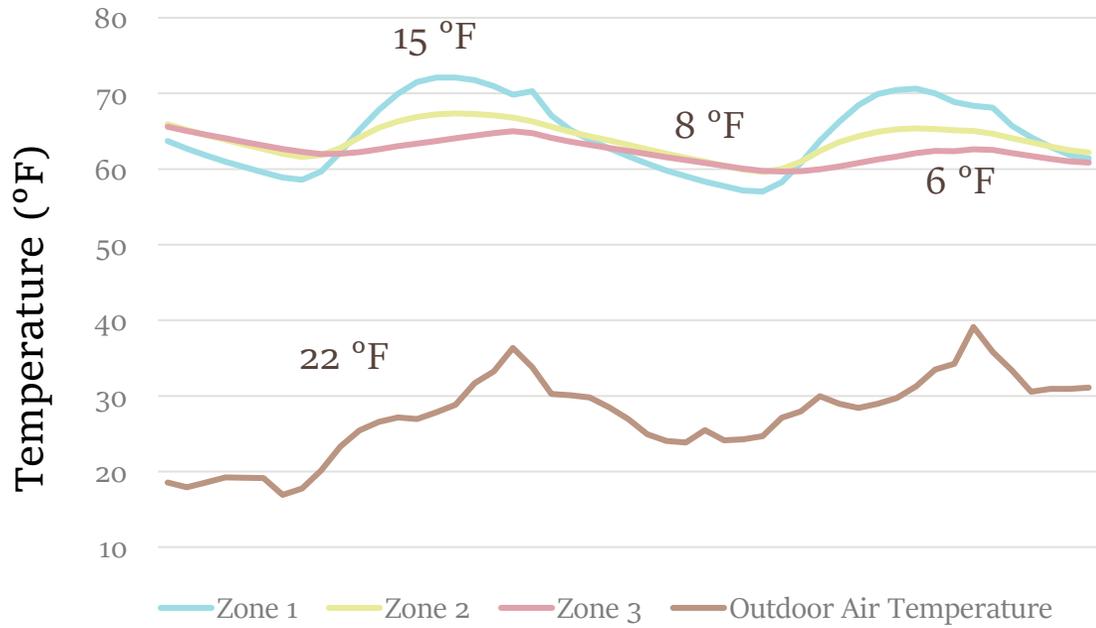
Annual Energy Production: 23,600 kWh

Annual Energy Consumption: 17,500 kWh

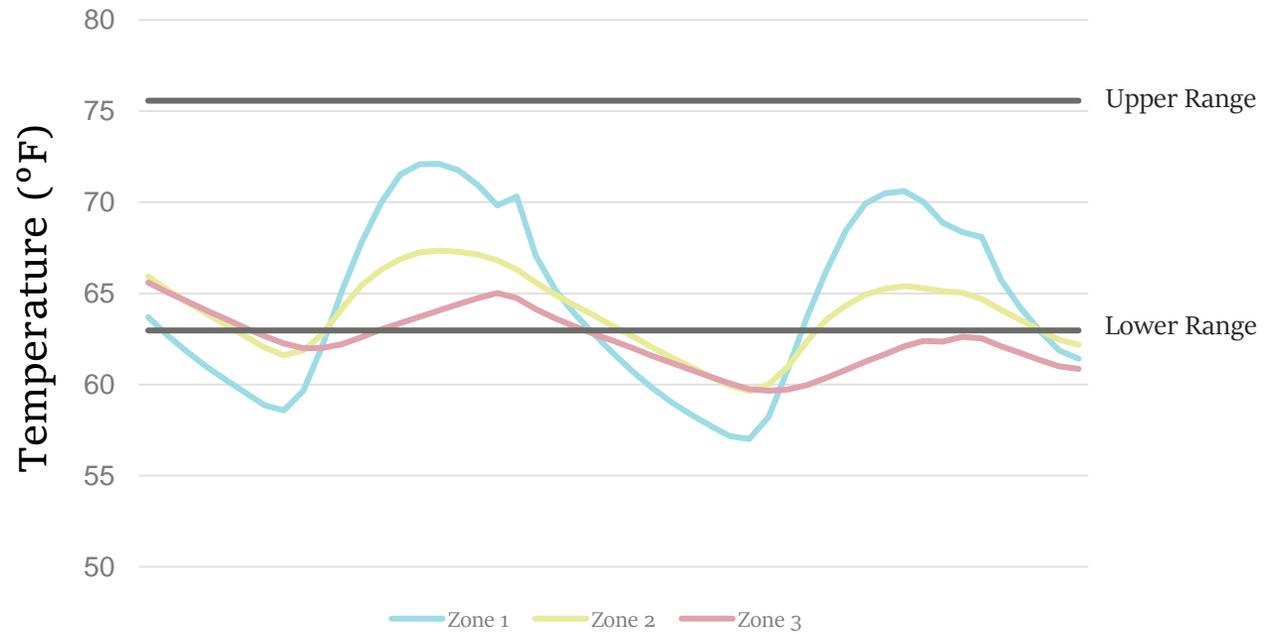
Average CO₂ levels <1000 ppm with 10 occupants for 3 hours!



Passive Performance: 4/6 - 4/8/2022



Zone and Outdoor Air Temperatures and Swings for Passive Performance Contest



Passive Zone Temperatures and Upper and Lower Adaptive Comfort Range





*Net
Positive!*



17,500 kWh
Annual Energy Use

23,600 kWh
Annual Energy Production



Energy Profile

32-panel PV array; 480W each



21 panels

required to operate the house
(Net-zero on an annual basis)

3 panels

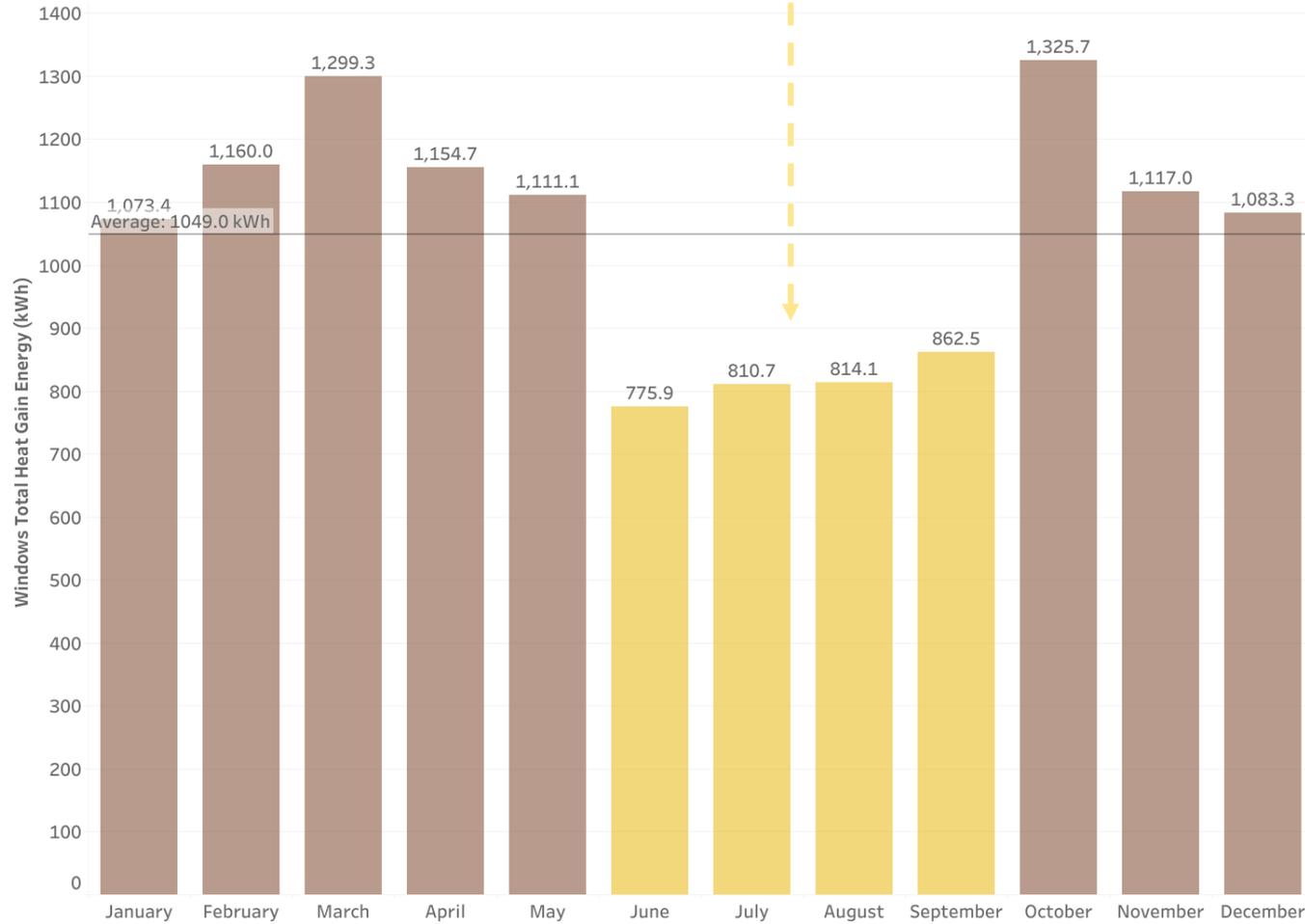
EV charging; 2 vehicles

8 panels

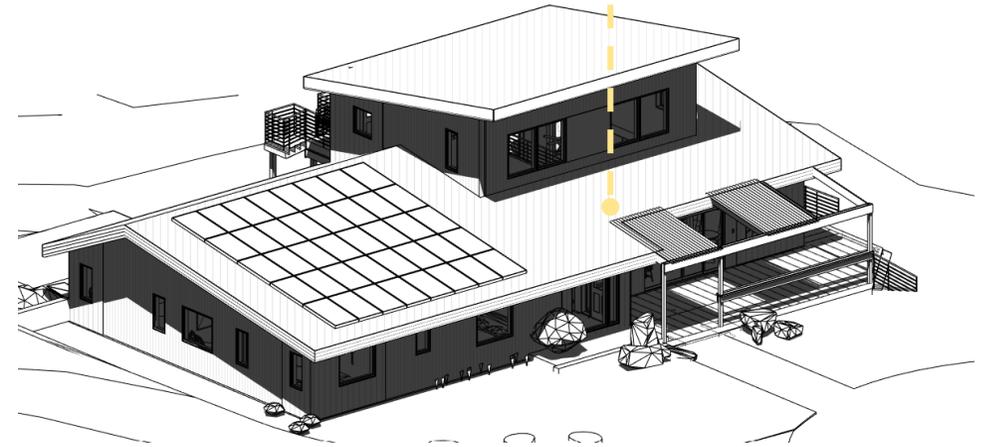
Surplus energy production



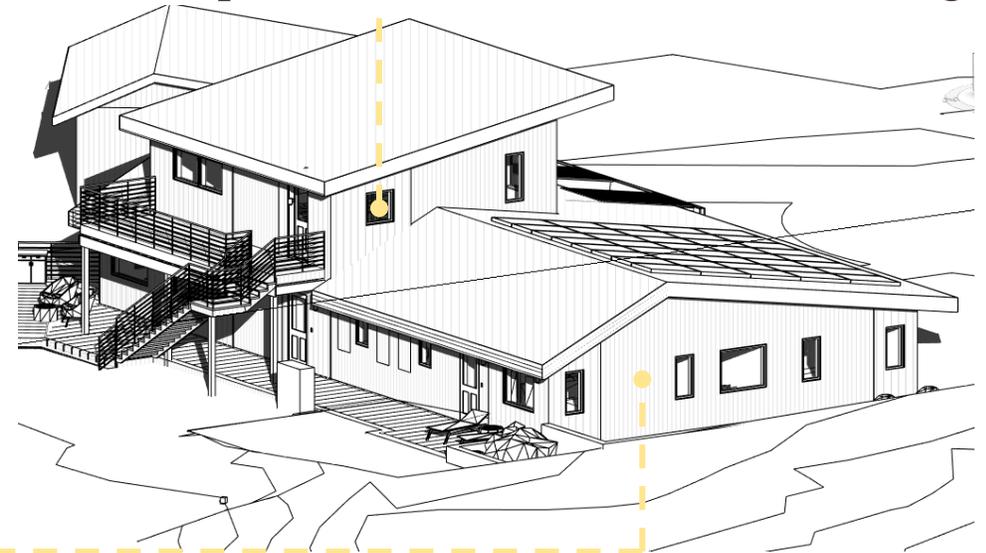
Passive Solar Heating



Retractable porch shade



Operable windows - less overheating



West windows - Retractable Exterior Blinds

Energy Plus simulation



ENGINEERING | Energy Performance





thank you!



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esniddio@gmail.com



emmanuel-iddio



Build Challenge Overall Winners



The Alley House is a 1,350 ft² duplex built with a community development corporation on a vacant infill lot and aims to address gentrification pressure and promote neighborhood revitalization.



1st Place:
Ball State University



Build Challenge Overall Winners



Team SHUNYA, meaning "zero" in Hindi, built a 1,416 ft² zero energy house with advanced technology solutions for a family in a growing city to help address air quality in a hot and humid climate.

2nd Place:
Indian Institute of Technology Bombay



Build Challenge Overall Winners



3rd Place:
University of British Columbia



Third Quadrant Design, named after the negative quadrant of the carbon-energy coordinate plane, built a 1,220 ft² structure located on the university campus that will provide experiential and research-based learning on zero-emissions, regenerative, and climate resilient design.