



# Solar+ Homes: If an Integrated Approach Works in a Retrofit Application, New Homes will be even Better

March 9, 2018

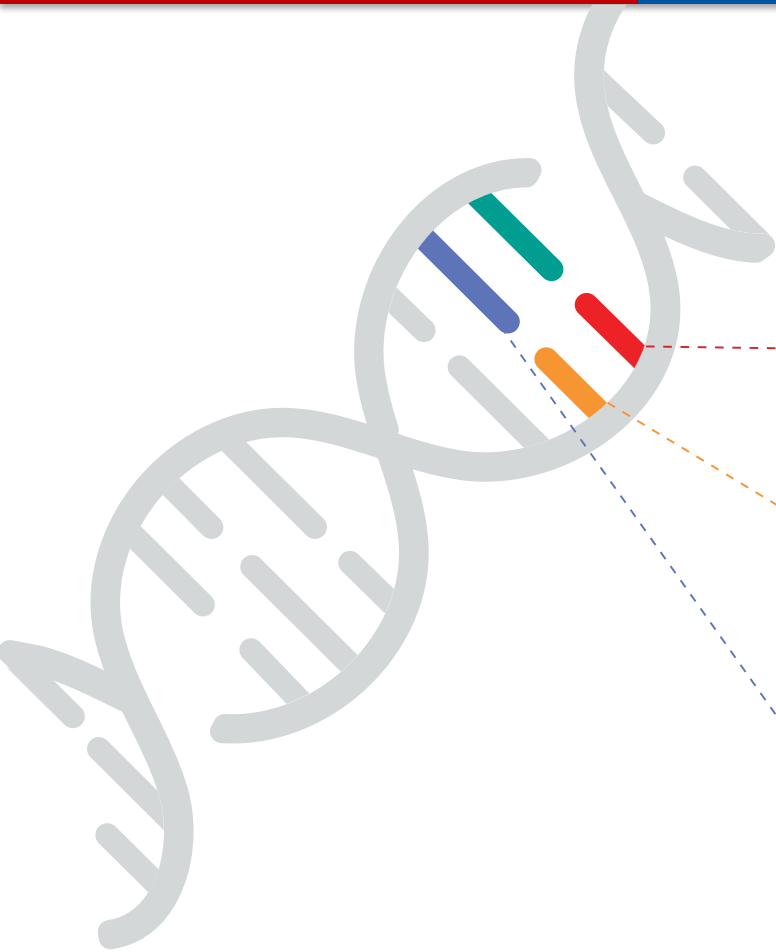
Tom Hoff

Founder and Chief Research Officer

[www.cleanpower.com](http://www.cleanpower.com)



Clean Power Research®



## Mission

Advancing  
the energy  
transformation

## Team

Utility, energy  
and software  
professionals

## Software

PowerClerk  
SolarAnywhere  
WattPlan

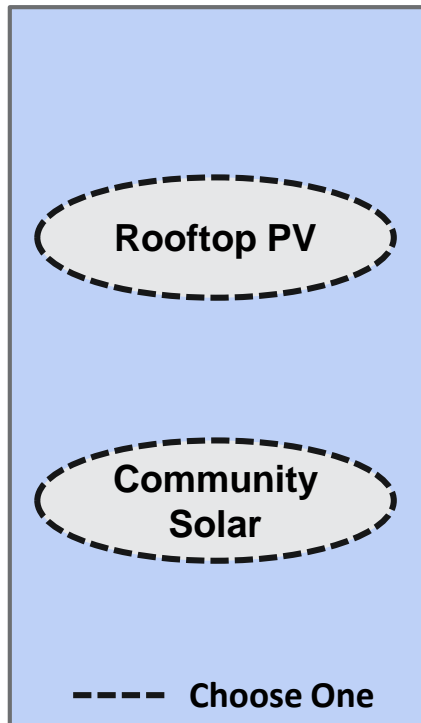


# Solar+ Storage

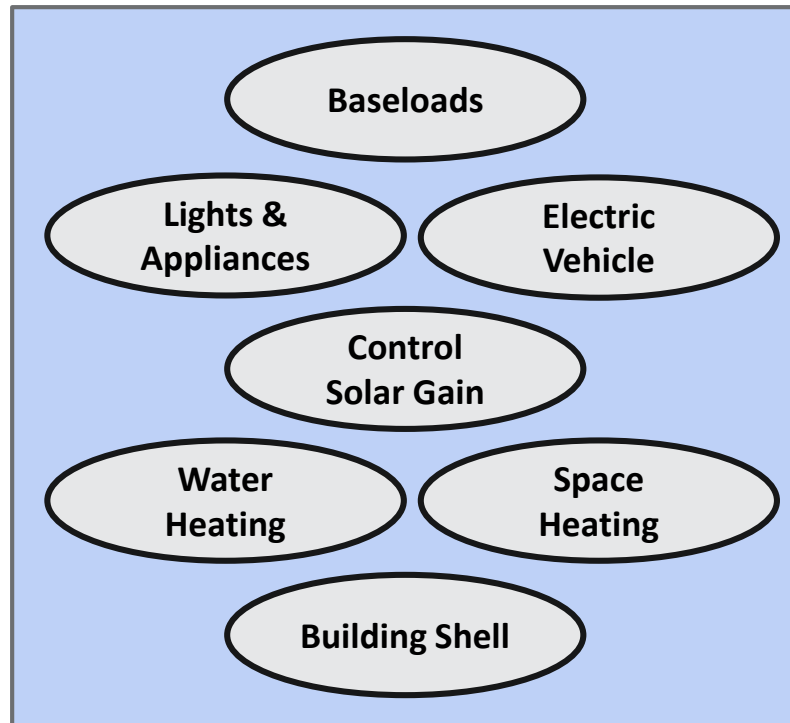


# Distributed Energy Resource Options

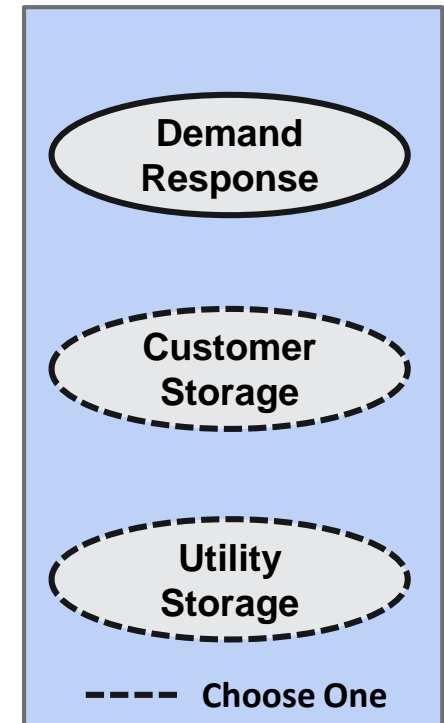
## Supply Investments



## Demand Investments

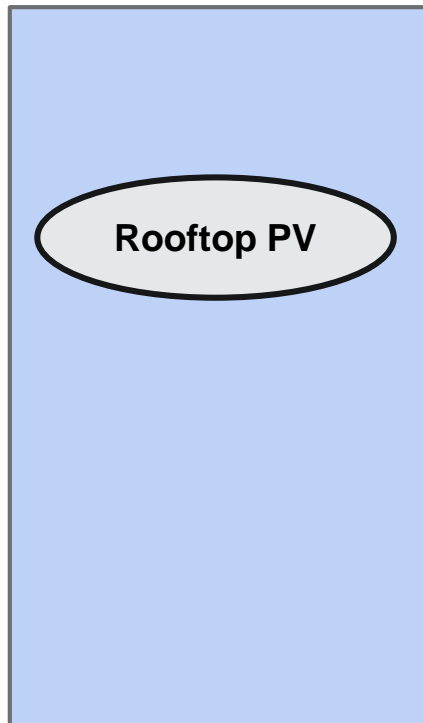


## Investments to Match Supply & Demand

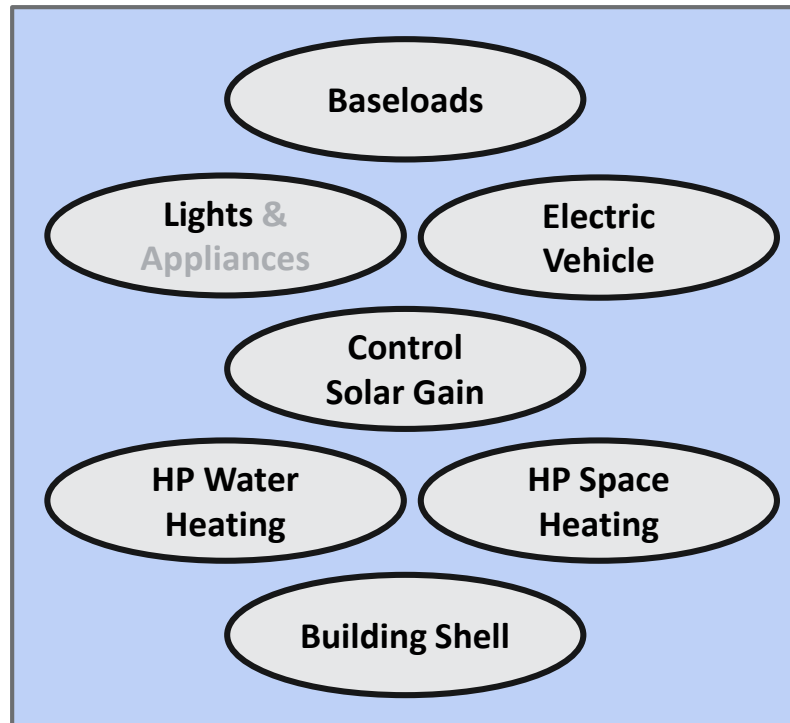


# Solar+ Home Retrofit in Napa

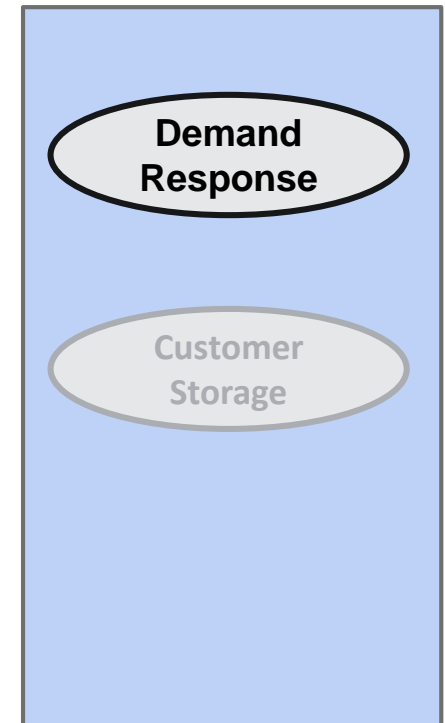
## Supply Investments



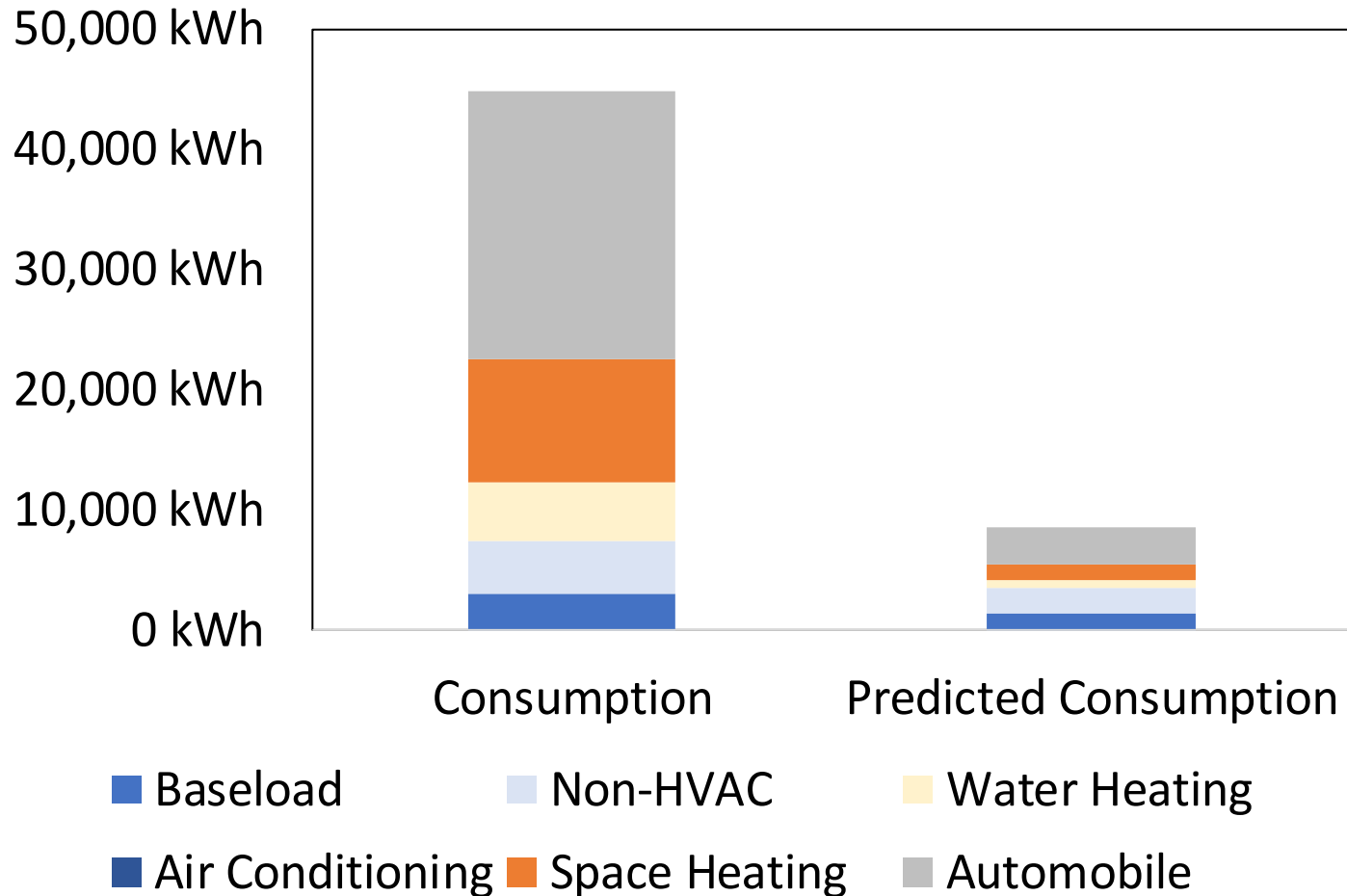
## Demand Investments



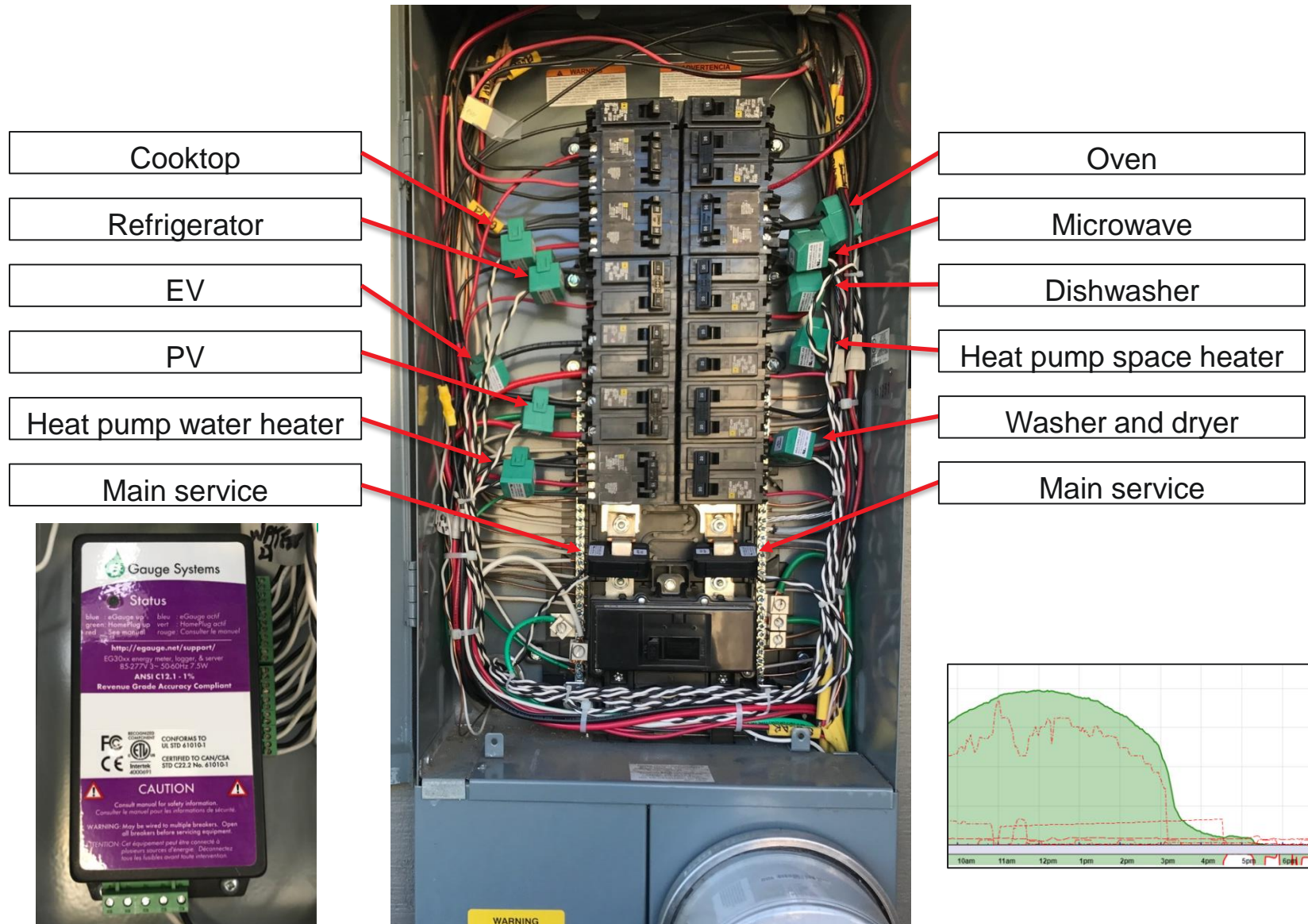
## Investments to Match Supply & Demand



# Solar+ Home Energy Consumption

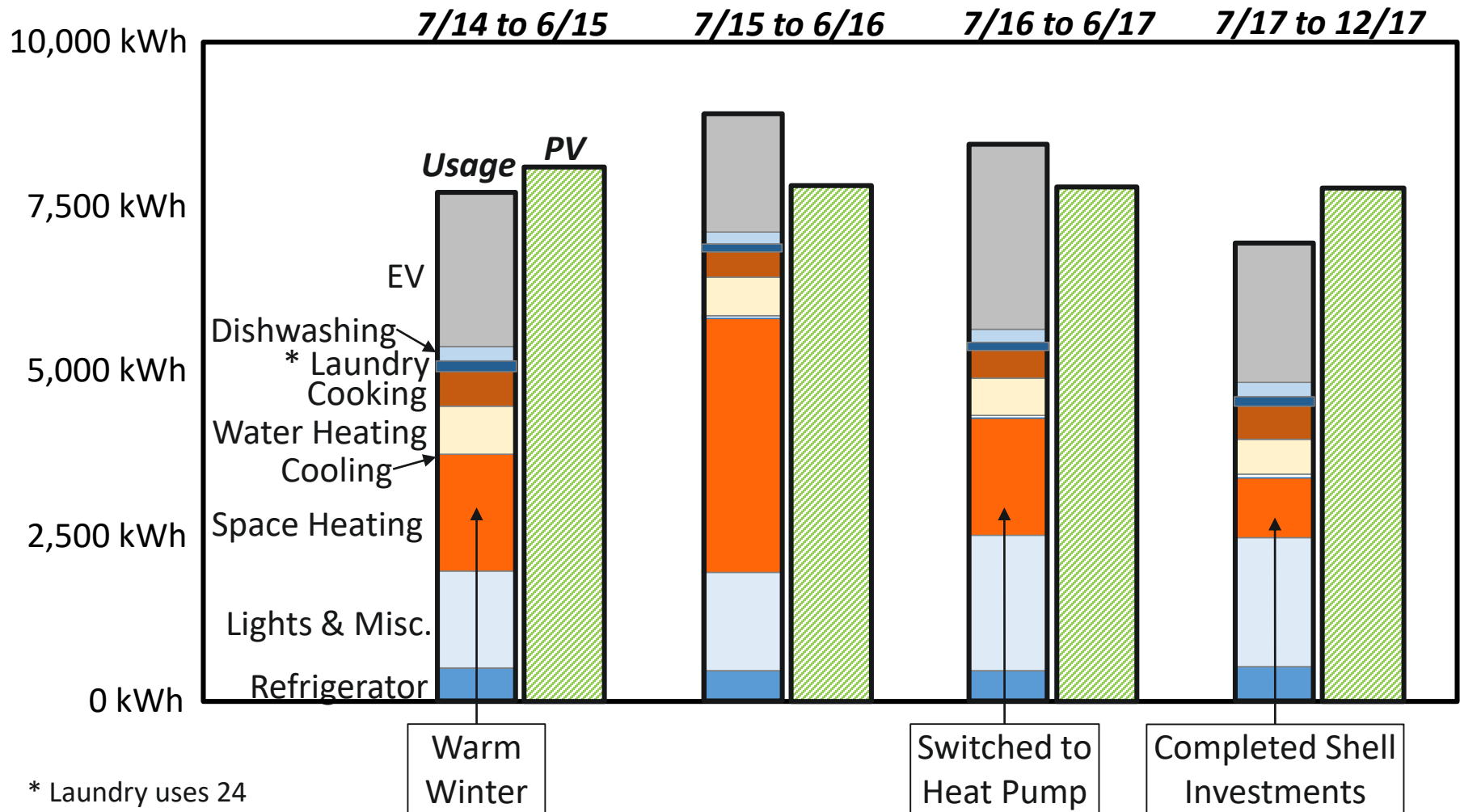


# Power Monitoring System





# Validation: 3½ Years of Results



\* Laundry uses 24  
therms of natural gas



Clean Power Research®



# Solar+ Home



*35 year old, 3,000 ft<sup>2</sup> House in Napa, CA*  
after installation of SunPower 6 kW-DC PV System



**Clean Power Research®**

# EV, Heat Pump Water Heater, Controls



Heat pump  
water heater  
controller

Heat pump  
water heater

Electric  
Vehicle

EV supply  
equipment

Variable rate  
charge  
controller

# Small Mini-Split Heat Pump Heats Entire Home

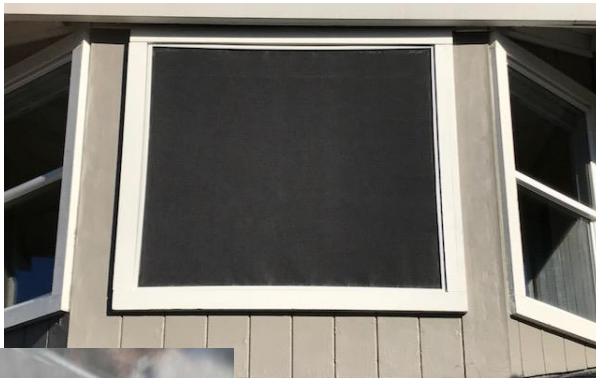
Thermally insulated  
shades

110V unit connects to  
wall socket



# Optimize Seasonal Window Screen Usage

**Shade south-facing windows in summer**



23 Btu/ft<sup>2</sup>-hr  
(6% solar heat gain)

**Remove screens in winter**



231 Btu/ft<sup>2</sup>-hr  
(~60% solar heat gain)\*

\*Measured value is comparable to reported window spec of 62% SHGC



**Clean Power Research®**



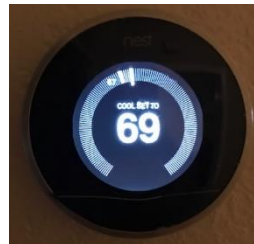
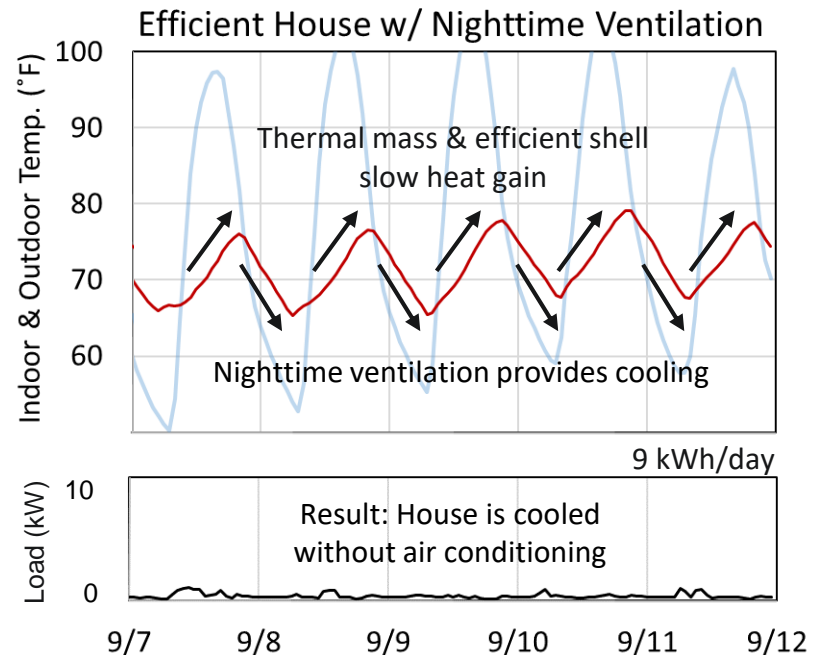
# Have Good Attic Ventilation using Passive Ventilation and Roof Shading



# Reduce AC Consumption using Thermal Mass and Nighttime Ventilation



## Hottest Week of 2015



Note: a similar, very inefficient house used 57 kWh per day during the same week

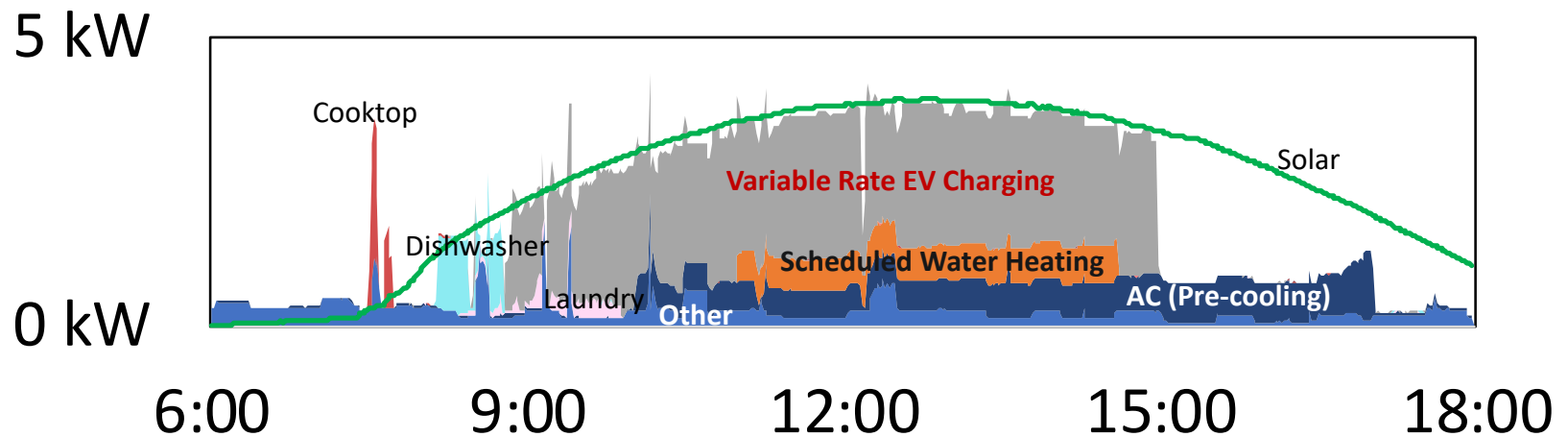


Clean Power Research®

# Schedule and Control Loads to Match PV

## July 7, 2017 (104° F day, Napa, CA)

### Load and PV Production



Measured 1-minute data

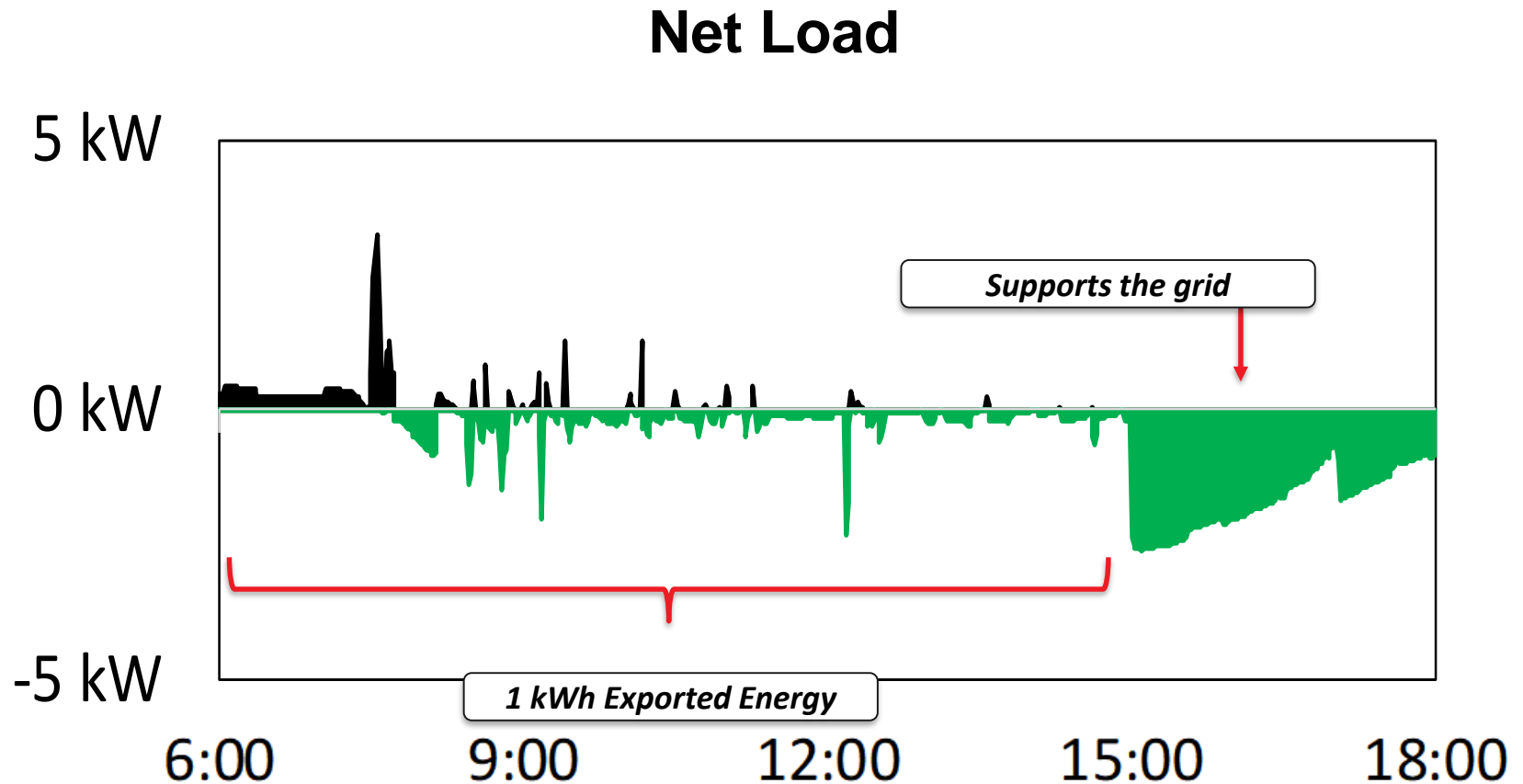


Clean Power Research®

Copyright © 2017-2018 Clean Power Research. All Rights Reserved.



# Result is Flat Net Load



# Conclusions

- Solar+ home is one that is fully powered by solar electricity, including water heating, space conditioning, and transportation
- Goal was to cost-effectively convert existing home to Solar+ home
- Home reached 85% Solar+ home and reduced CO<sub>2</sub> emissions from 13.5 tons to 1.5 tons

