

# CALFLEXHUB SYMPOSIUM



**PETER GRANT**



**MATT ELLIS**



**SUBHRAJIT CHAKRABORTY**



**TRISTAN DE FRONDEVILLE**

## PROJECT SHOWCASE

Water Heating Technologies,  
Commercial and Residential

### KEYNOTE SPEAKERS:

**Peter Grant, Senior Scientific Engineering Associate, Berkeley Lab**

**Matt Ellis, Assistant Professor, Department of Chemical Engineering, UC Davis**

**Subhrajit Chakraborty, R&D Engineer, Western Cooling Efficiency Center, UC Davis**

**Tristan de Frondeville, CEO, SkyCentrics**

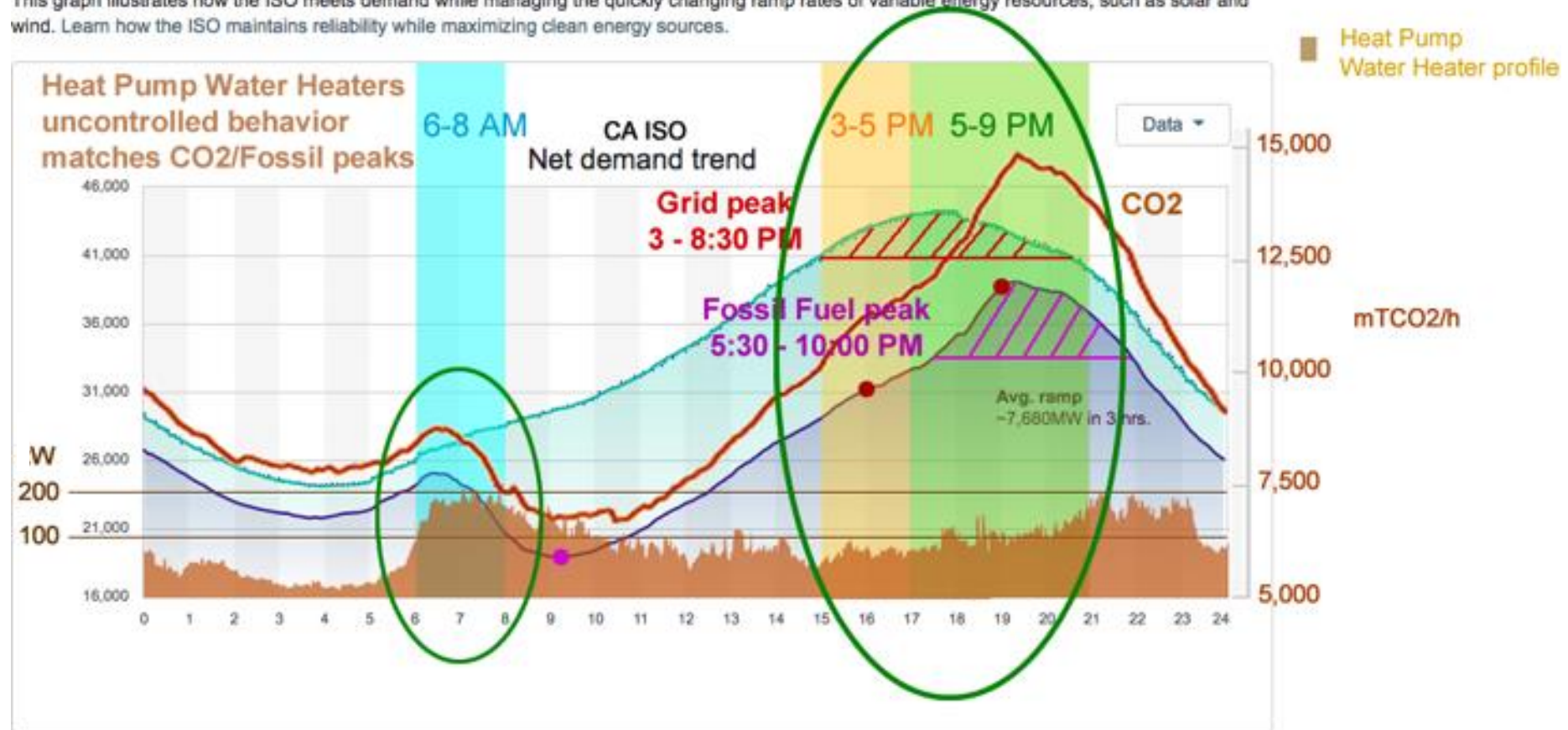
# 2022



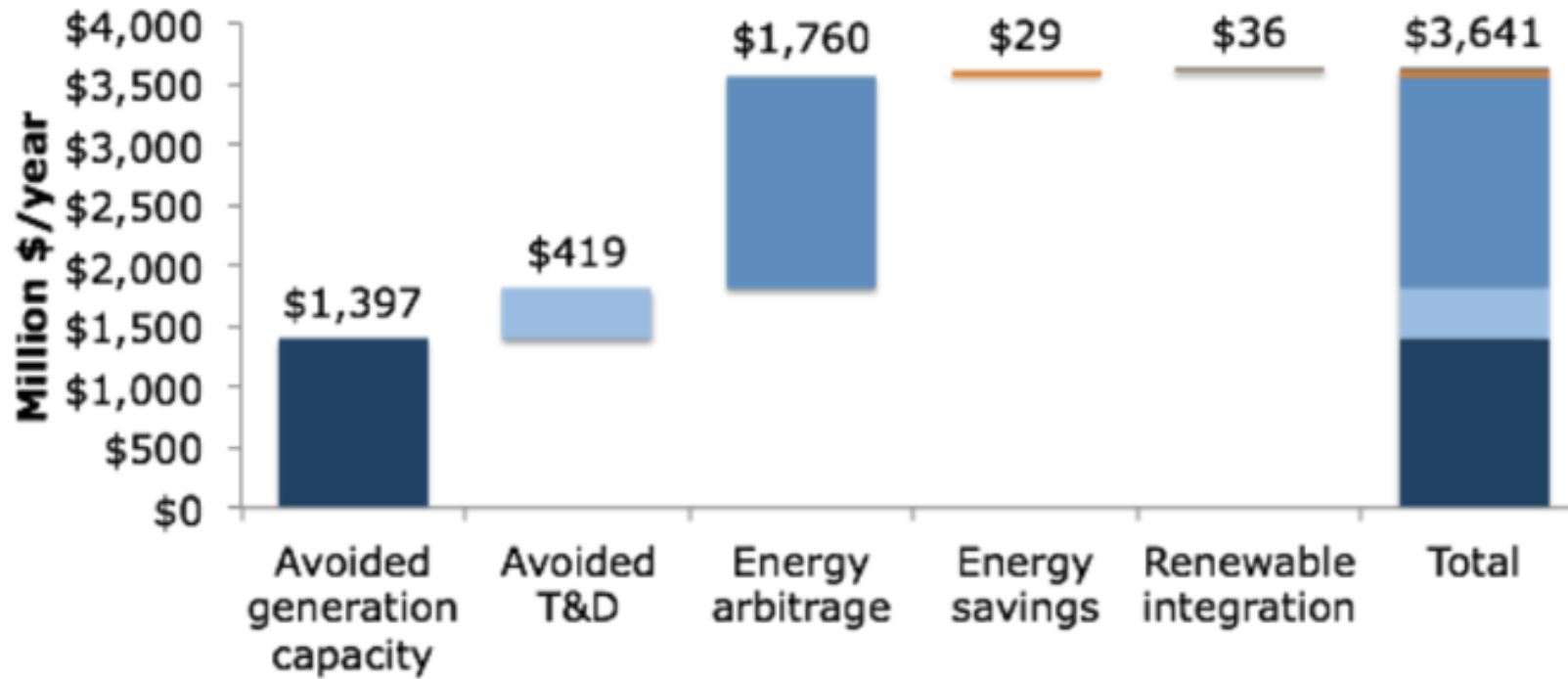
# Business case for connected heat pumps

## Net demand (demand minus solar and wind) AS OF 15:20

This graph illustrates how the ISO meets demand while managing the quickly changing ramp rates of variable energy resources, such as solar and wind. Learn how the ISO maintains reliability while maximizing clean energy sources.



# The value of grid connected water heaters - 2018

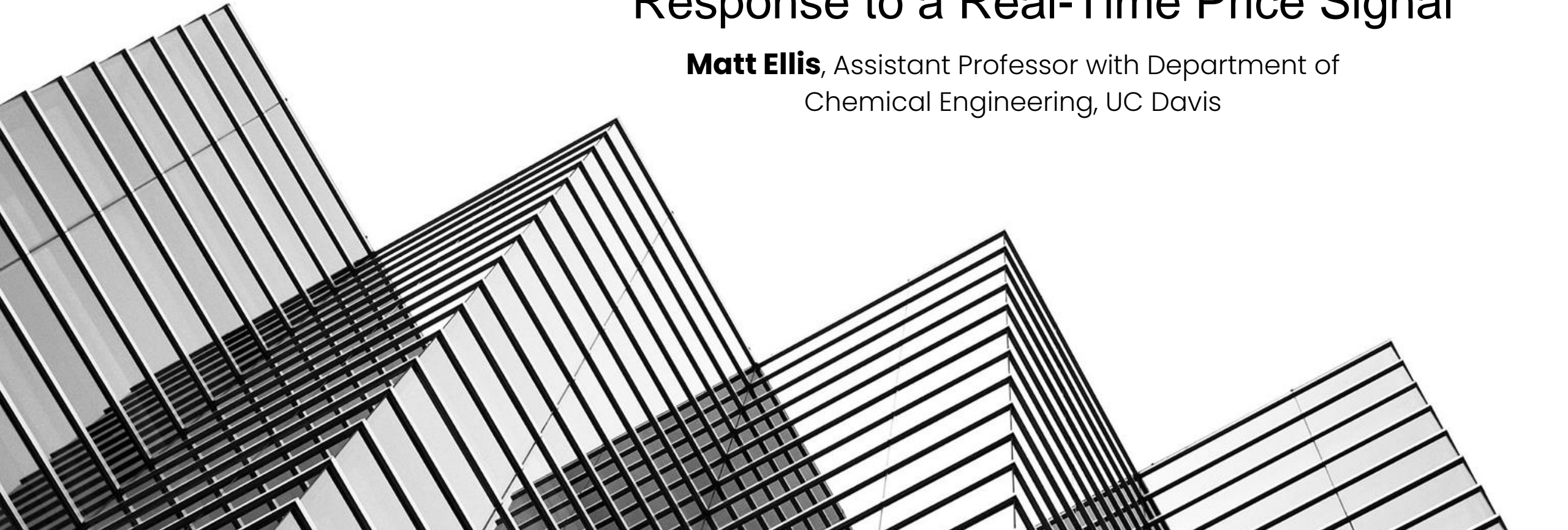


\$3.6 billion/year in value from a grid-interactive fleet of water heaters. Source: RMI.



# Optimizing Heat Pump Space Conditioning and Domestic Hot Water Load Flexibility in Response to a Real-Time Price Signal

**Matt Ellis**, Assistant Professor with Department of  
Chemical Engineering, UC Davis





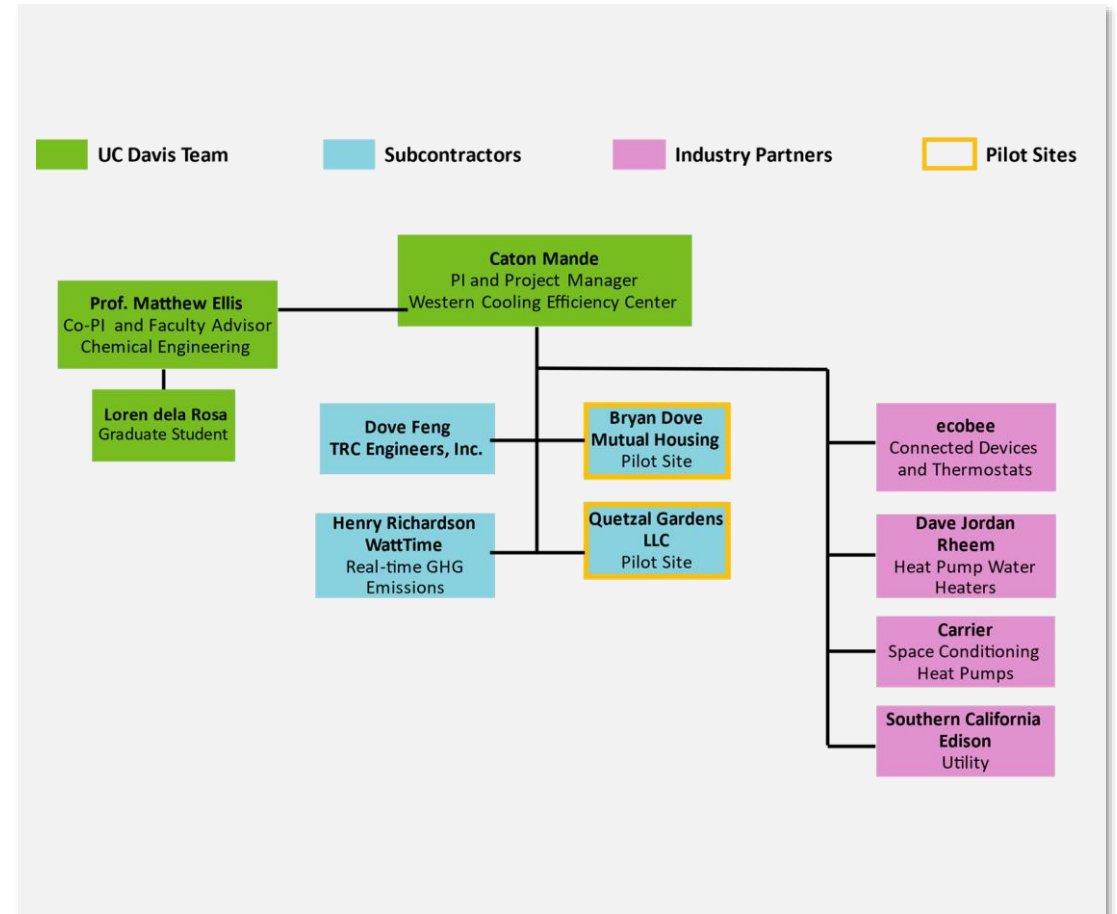
# Cal Flex Hub Project A2: Optimizing Heat Pump Space Conditioning and Domestic Hot Water Load Flexibility in Response to a Real-Time Price Signal

*Professor Matt Ellis*

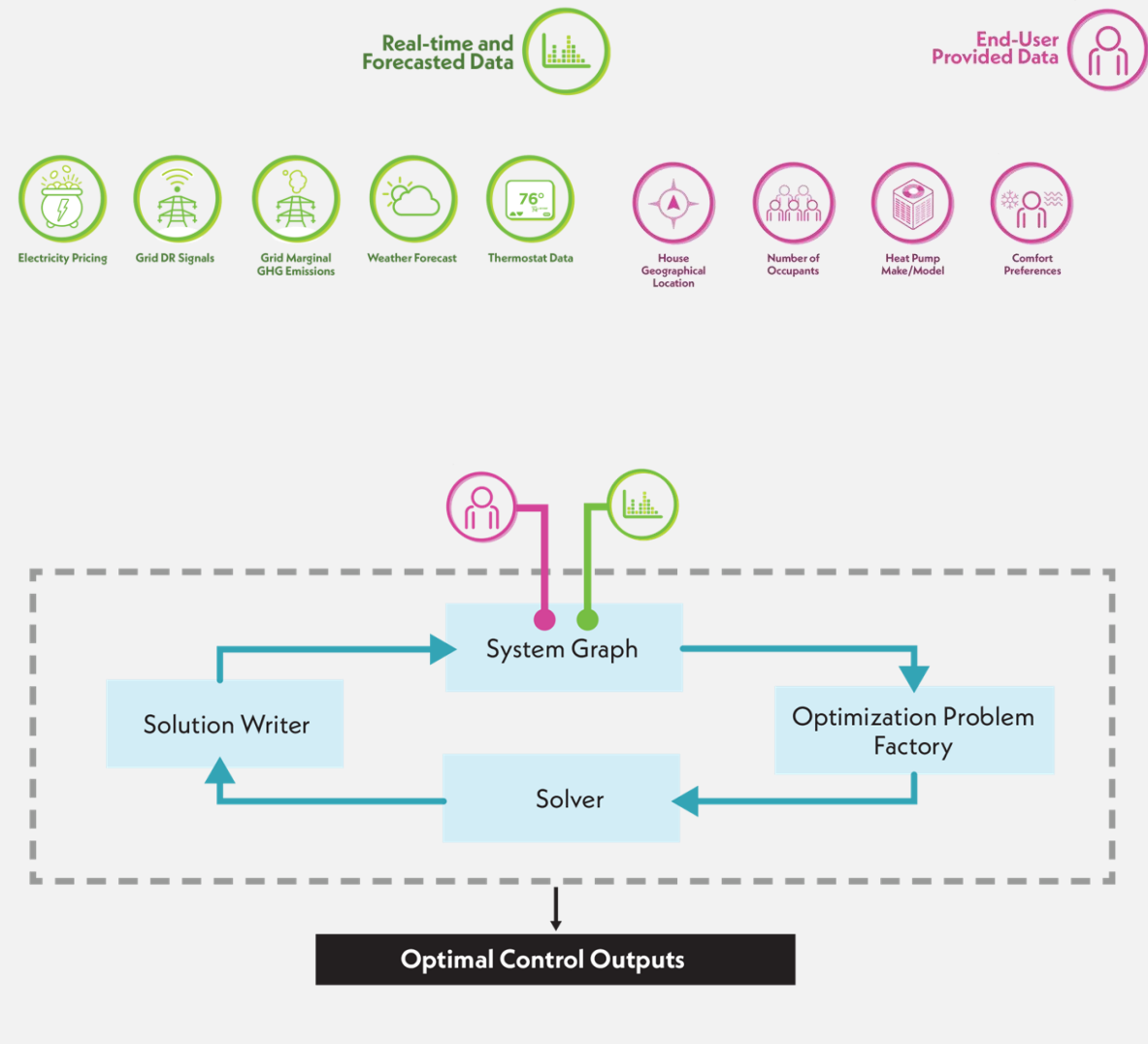
# Project Overview

- » Model predictive control (MPC) for residential heat pumps
  - Uses predictive models
    - Predict load flexibility capability
    - Maintain occupant comfort
    - Meet occupant hot water demand
  - Makes control decision over a prediction horizon accounting for
    - Real-time price signals
    - Weather
    - GHG emissions

# Project Team



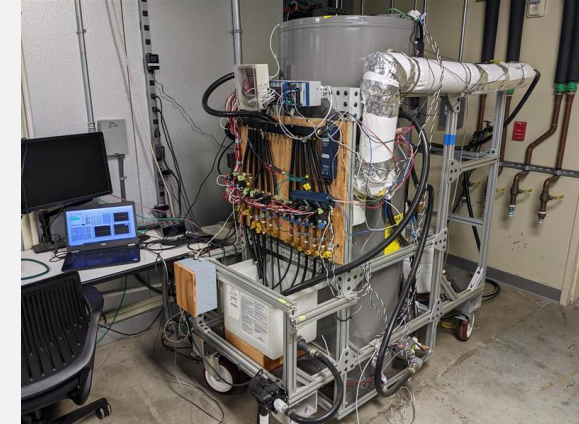
# Control Approach



# Lab/Field Sites

## Lab Setup:

- Fully instrumented and identical equipment as field sites
- Replicate any load profile with flows from 0.01 to 9 GPM
- Will be placed in environmental chamber to control air temperature during tests



## Field Sites:

- Two apartment complexes (28 total participants)
  - Woodland, CA (CCZ 12)
  - San Jose, CA (CCZ 4)
  - Participants include 1, 2, and 3-bedroom units



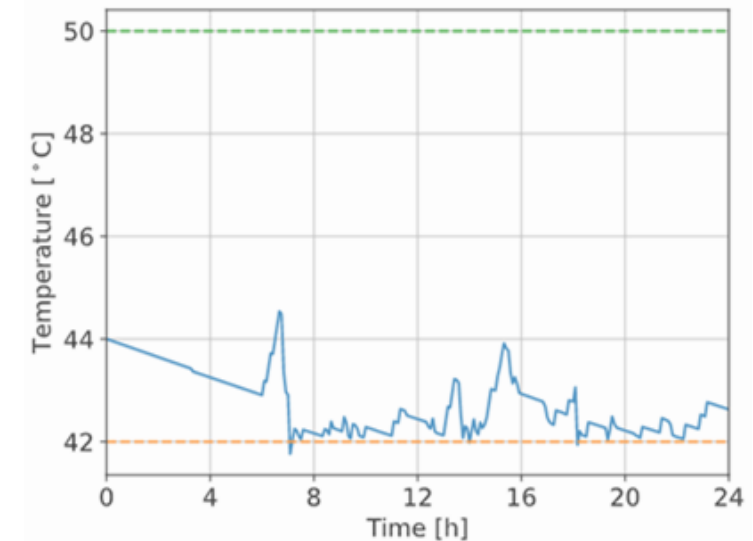
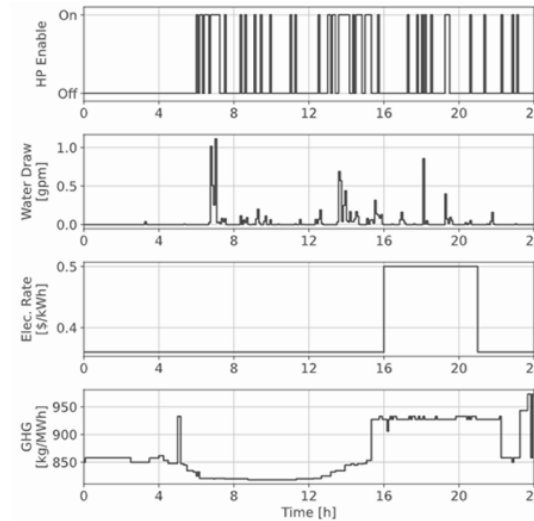
# Lab and Modeling Work

## » Modeling

- High fidelity tank model based on Nash et. al.
- Simulates entire process including API calls for testing DR and price signals
- Early results show significant reduction of GHG and cost, but work is ongoing

## » Lab Setup

- Fully instrumented and identical equipment as field sites
- Can replicate any load profile
- Will be placed in environmental chamber for simulated air temperature profile



Inputs (left) optimized to reduce GHG results in a temperature profile (right) and a 30% reduction in GHG over 24 hours.



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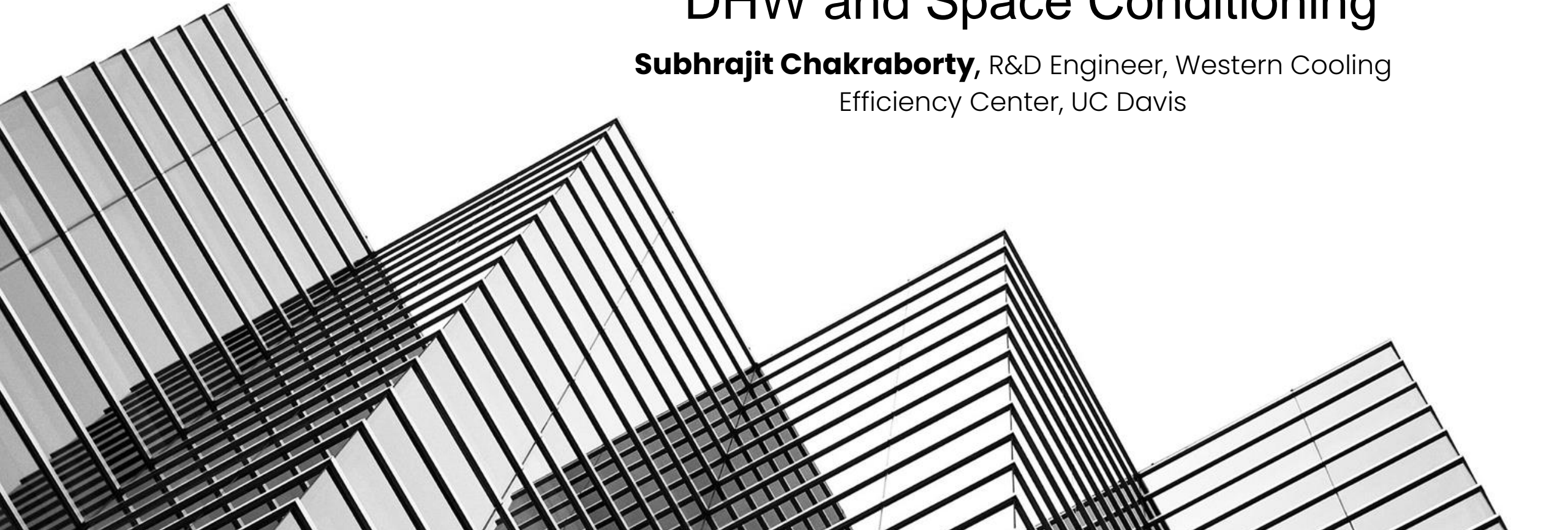
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# Integrated Heat Pump with Storage for DHW and Space Conditioning

**Subhrajit Chakraborty**, R&D Engineer, Western Cooling  
Efficiency Center, UC Davis



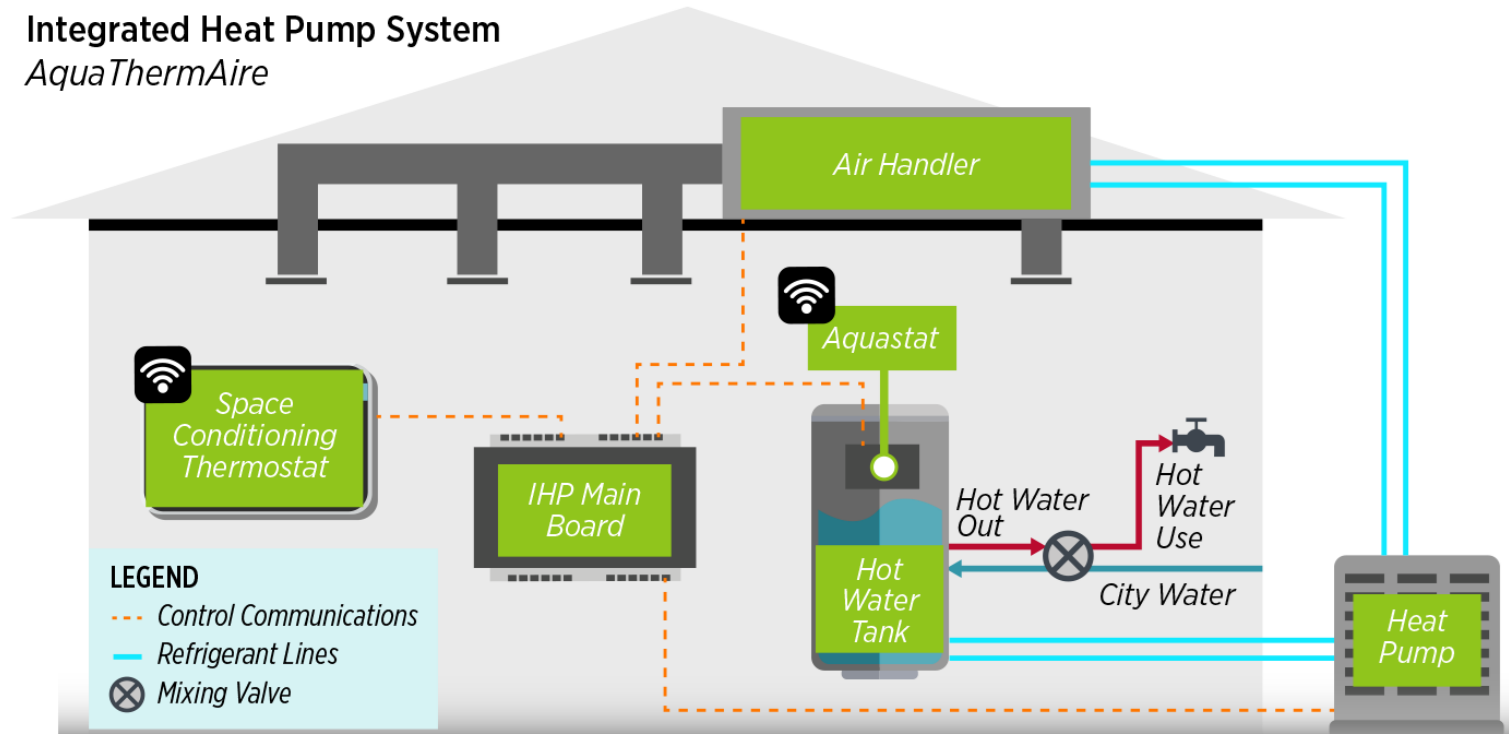
# Integrated Heat Pump with Storage for DHW and Space Conditioning

## Brief Project Description:

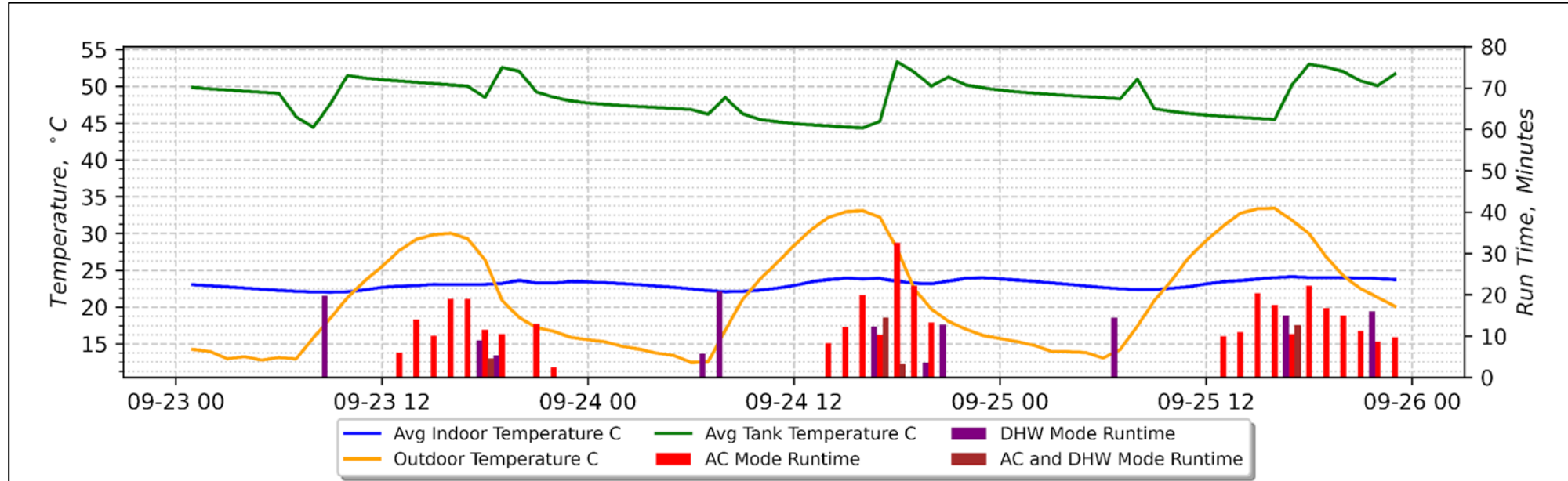
- Air-to-air heat pump providing easy retrofit in existing homes
- IHP board and AquaStat with remote connectivity developed by Villara in collaboration with WCEC
- A cloud server with control algorithms computes setpoints for AquaStat and ThermoStat

## Lab/Test Site(s):

- Single-family home (2000 sq. ft) in Davis, CA



# Summer Baseline Results



## Summer baseline monitoring

- Met space cooling and DHW loads of the household
- Operated in three modes
  - AC mode for space cooling
  - DHW mode for water heating
  - Simultaneous AC and DHW mode (infrequently)
- AC and DHW mode → 25% higher average efficiency

## Installation of the DHW tank without:

- Inlet and exhaust air connections
- High voltage power outlet
- Electric resistance heaters

# Integrated Heat Pump with Storage for DHW and Space Conditioning



Subhrajit Chakraborty  
R&D Engineer 3



David Vernon  
Co-Director Engineering



Timothy Levering  
R&D Engineer 2

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Website: <https://wcec.ucdavis.edu>



# Shifting Loads with Heat Pump Water

**Tristan De Frondeville**, CEO, SkyCentrics



# Heat Pump Water Heater Control



CEO



CTO

Contact Information: [info@skycentrics.com](mailto:info@skycentrics.com) 415.962.1500

# Heat Pump Water Heaters (Res/Com)

CTA-2045 EcoPort Heat Pump Water Heaters installed in residential homes and in bay area city government buildings

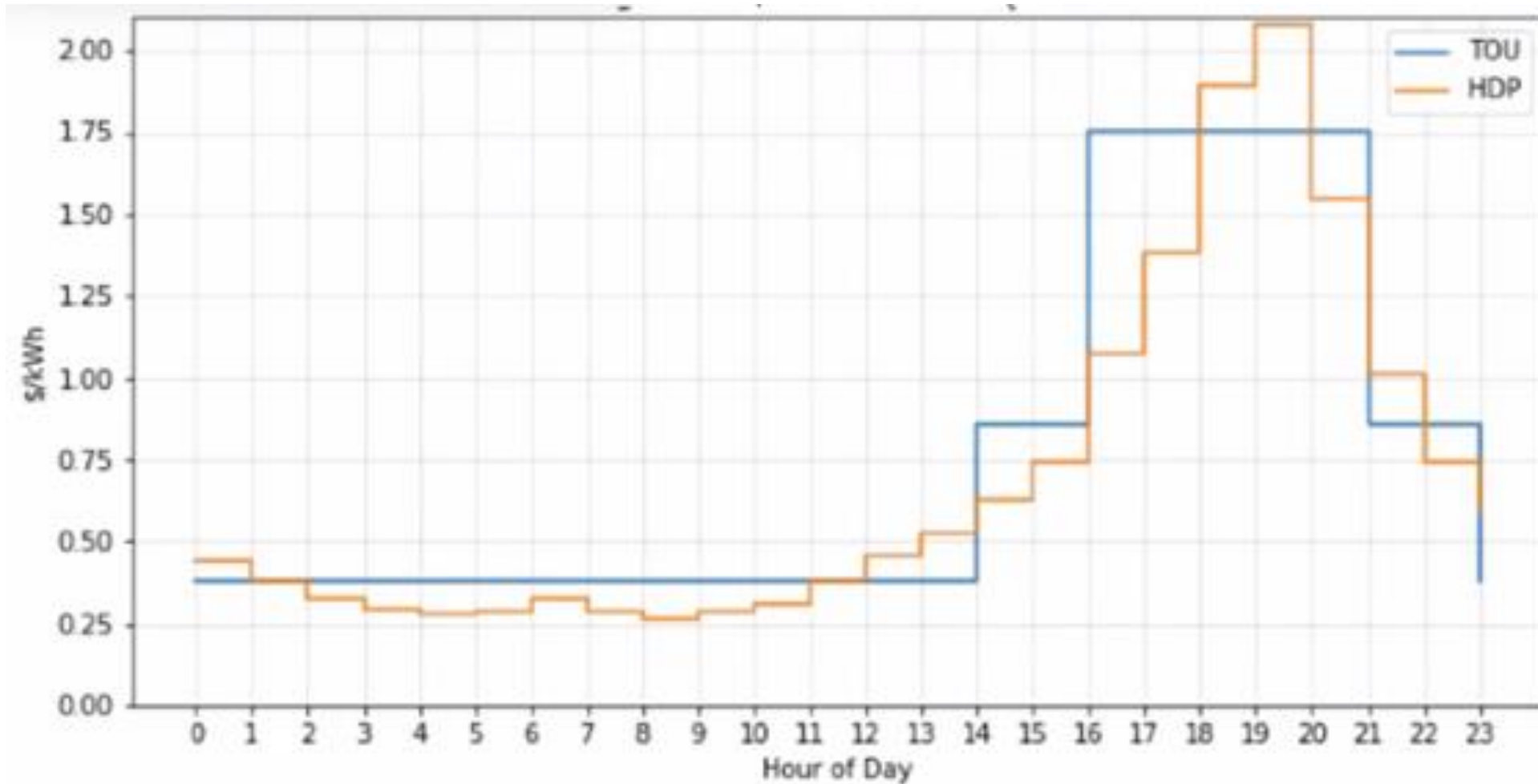
- *Price/GHG Signal from CFH Price Server and MIDAS*
- *Translated to an “Action Shape”*

Residential homes and city government buildings in the Bay Area





# Action Plan based on TOU

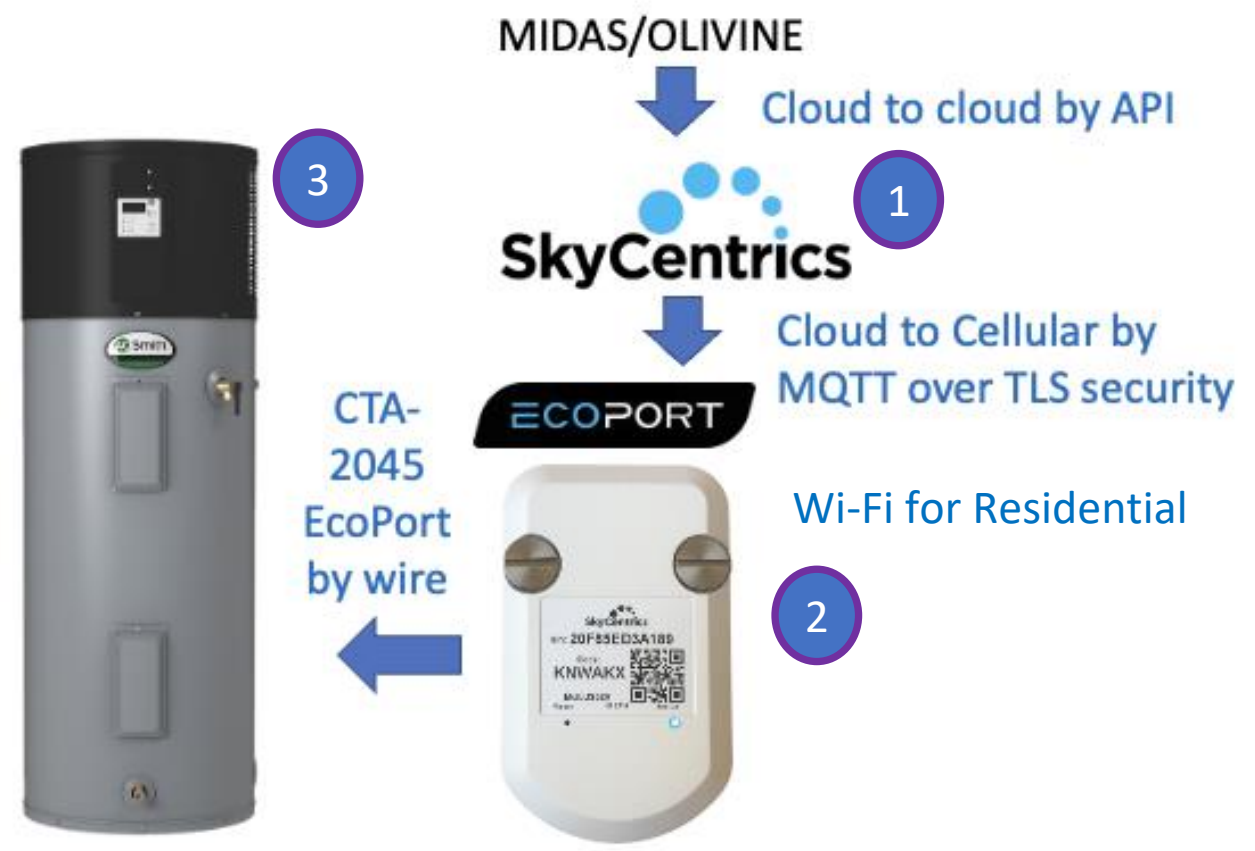


# Where is the Schedule?

- 1
- 2
- 3

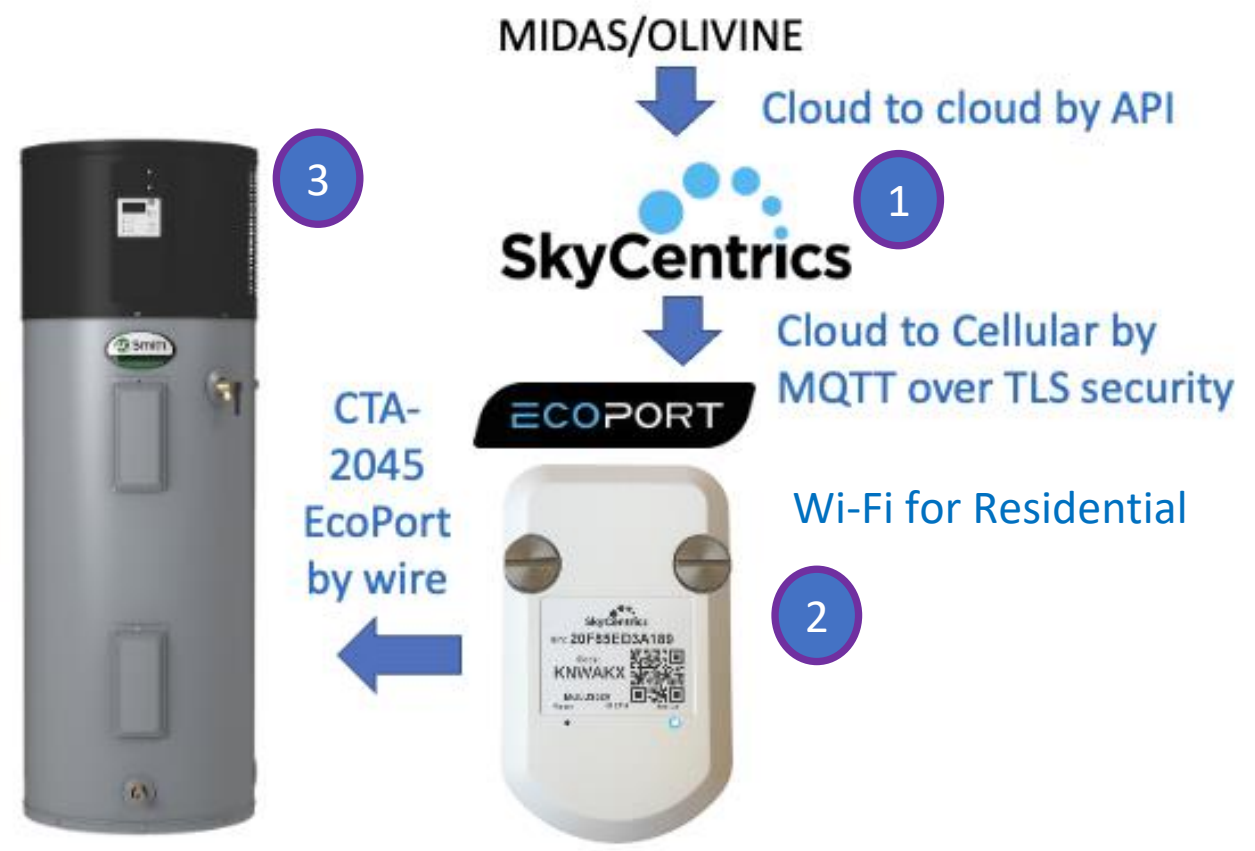
It is important to always know where a schedule can be stored and actually is stored.

Why is the cloud a bad place to store the action plan schedule?



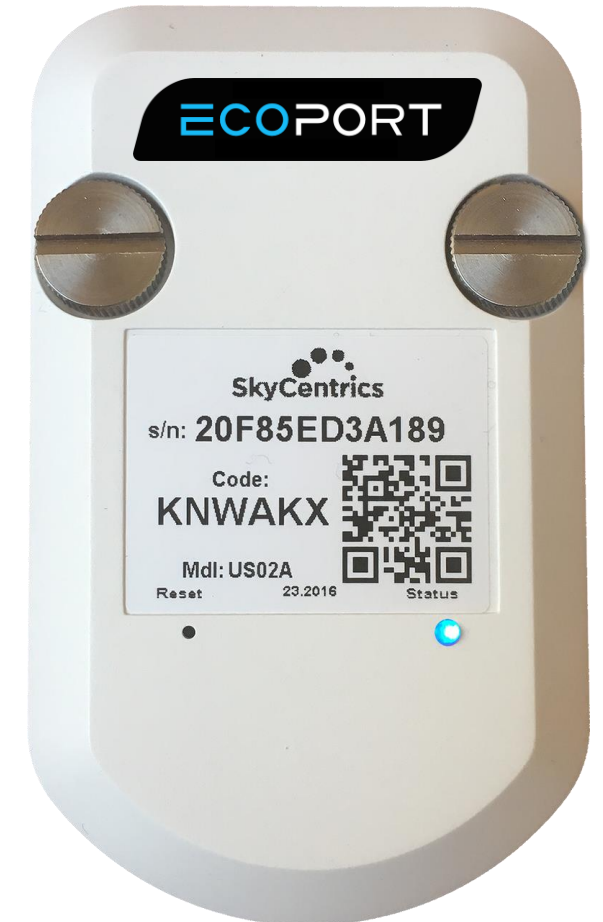
# Where is the Action Plan made?

Over time, the smarts to digest a price shape create the Action Plan will be pushed deeper to the edge device.



# CTA-2045 EcoPort Advantages

- CTA-2045 EcoPort water heaters are great for time shifting because they can Load Up before a shed, and they have cold-water prevention algorithms.
- They also have the ability to do an Advanced Load Up when a mixing valve is in place.
- In the next version of CTA-2045, the water heater will be required to be able to digest the price shape itself.



# Residential vs Commercial

- Residential peak matches grid peak

Net demand (demand minus solar and wind) AS OF 15:20

This graph illustrates how the ISO meets demand while managing the quickly changing ramp rates of variable energy resources, such as solar and wind. Learn how the ISO maintains reliability while maximizing clean energy sources.

