CALFLEXHUB SYMPOSIUM

NOVEMBER 3 | 8am-4pm PT


SUBHRAJIT CHAKRABORTY


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PROJECT SHOWCASE: RESIDENTIAL TECHNOLOGIES FOR EQUITABLE ADOPTION

SPEAKERS: Subhrajit Chakraborty, R&D Engineer, UC Davis; **Pierre Delforge,** Head of Product & Operations, Harvest Thermal; **Joe Bourg,** Vice President, Olivine; **Jingjing Liu,** CalFlexHub Program Manager, Berkeley Lab; **Nick Dirr,** Senior Director, Programs, Association for Energy Affordability; **Nicole Bloom,** Special Projects Manager, GRID Alternatives; **Therese Peffer,** Associate Director, UC Berkeley

2023

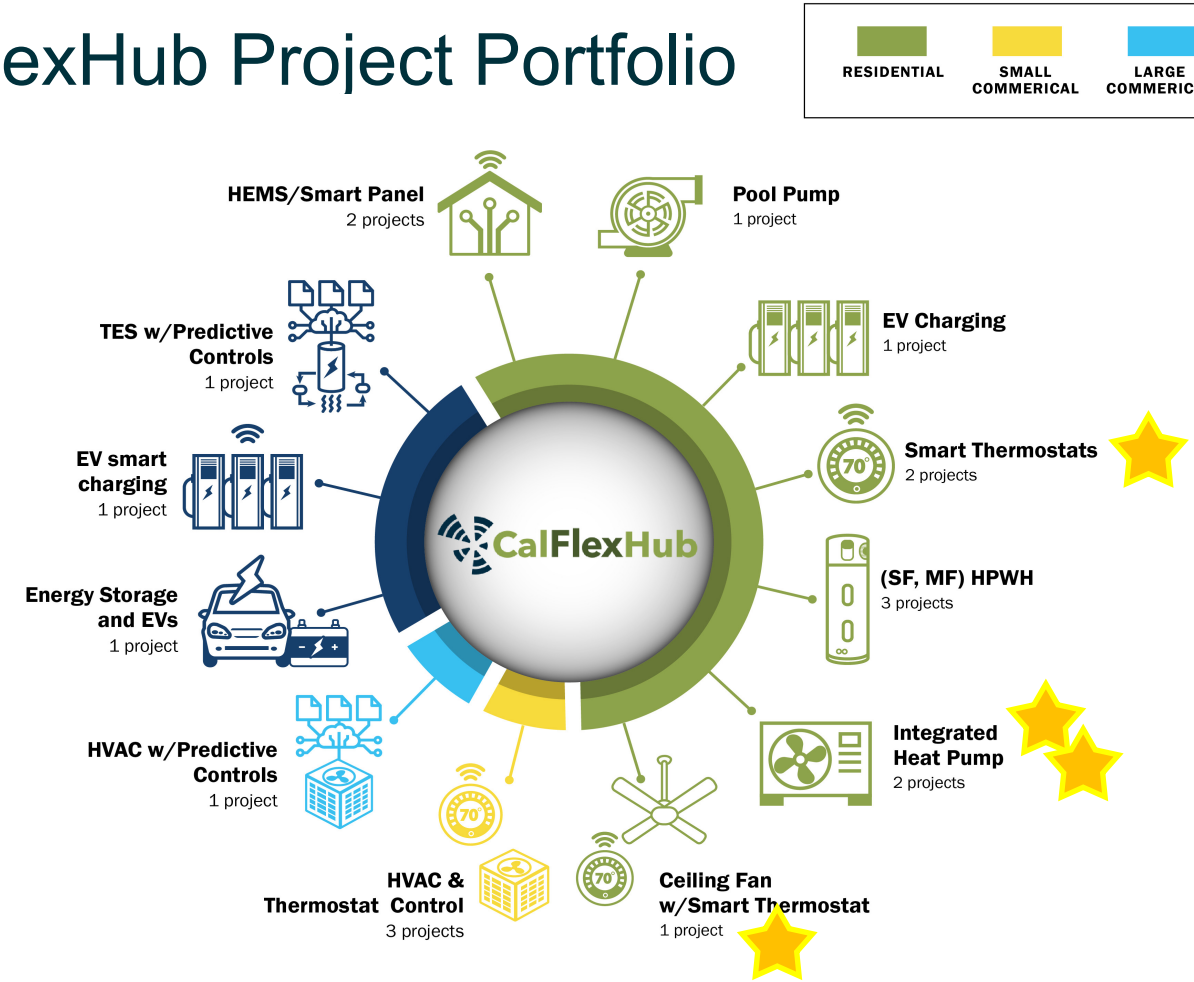
CalFlexHub

BERKELEY LAB

STATE OF CALIFORNIA ENERGY COMMISSION

MOMENTUM

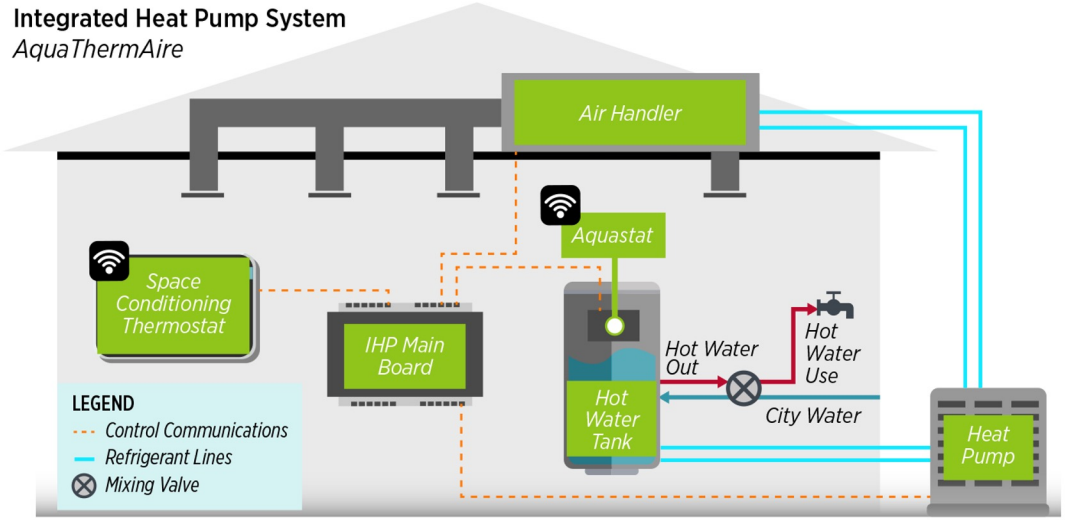
CalFlexHub Project Portfolio



#CALFLEXHUB23

Integrated Heat Pump with Storage for DHW and Space Conditioning

UCDAVIS
Western Cooling Efficiency Center
Part of the Energy and Efficiency Institute



- Air-to-air heat pump providing easy retrofit in existing homes with a central AC and/or furnace heating system
- Single compressor for Space cooling/heating and DHW needs

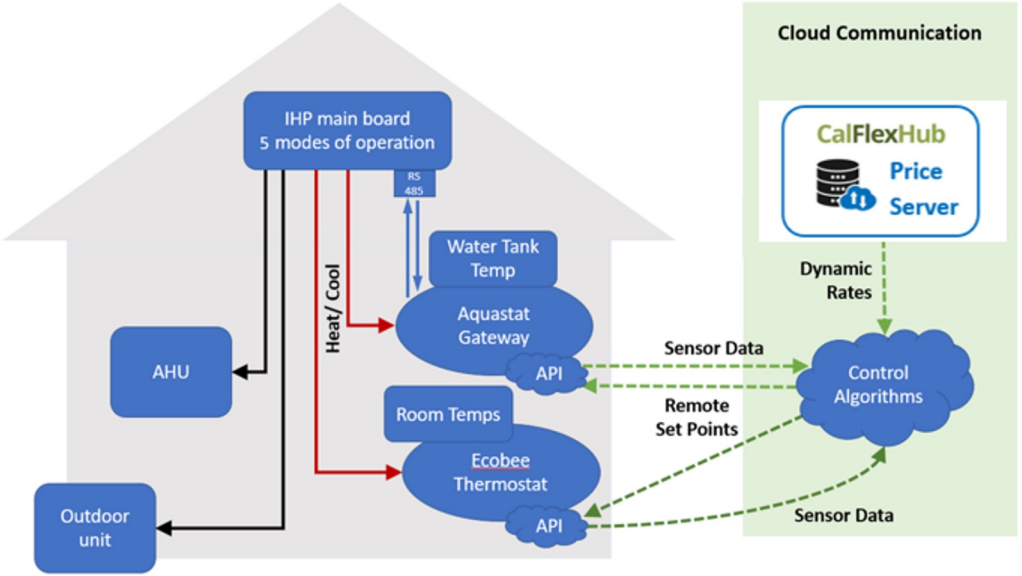
Test Sites:

- One SF home in Davis (PG&E);
- Two DAC/LI MF homes in Central Valley (PG&E)

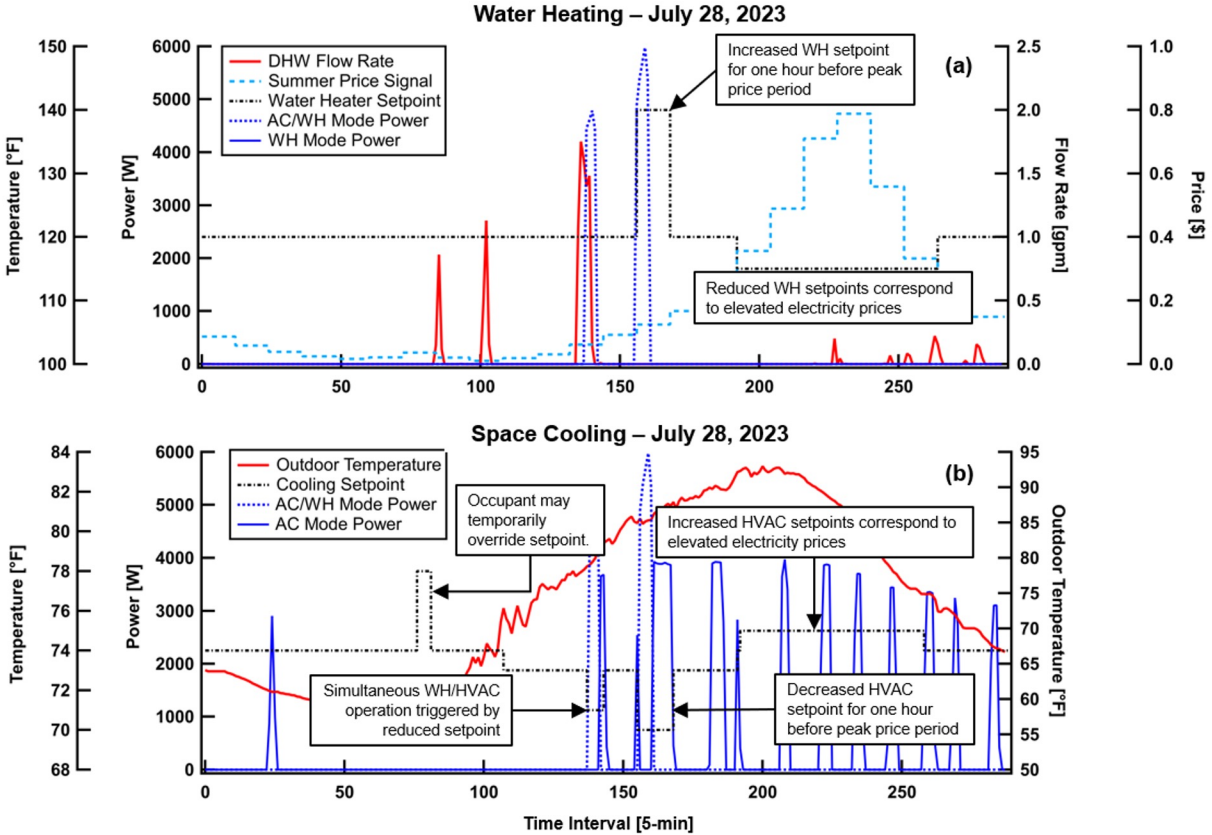
Sector/Building Type	Residential; SF/MF homes
Technology & End Use	Integrated Multi-Function Heat Pumps; cooling / heating / water heating
Communication Pathway	Research cloud -> Thermostat and Aquastat -> IHP main board -> AHU, HP outdoor unit
Expected Grid Benefit	Both today's summer peak reliability issue and future winter morning peak
Testing Status (Season/signal tested)	Water heating and HVAC load flex testing (Apr-present) (spring/summer price signal)

Communication Architecture

- Wi-Fi enabled space conditioning thermostat (Ecobee)
- Wi-Fi enabled water heating thermostat (Aquastat)
- Research cloud server with control algorithms
  - Receives GHG and price signals CFH price server
  - Receives sensor data from Aquastat and Thermostat API
  - Computes and communicates setpoints for AquaStat and ThermoStat
  - IHP board receives the heat/cool call and decides the operation of AHU and outdoor unit



Load Flex Test Results



- Water temperature setpoint optimization (100-140°F)
- HVAC size compressor can quickly charge DHW tank
- Improved algorithm with a shorter charging period before the peak reduced heat loss and kWh
- Load flexibility (LF) avoided WH operation during peak
- AC setpoint optimization by algorithm (70 -75°F) – highly dependent on occupants
- Algorithm triggers simultaneous AC/WH which has higher efficiency by lowering AC setpoint
- HVAC LF did not avoid AC operation during peak but decreased HP cycling in comparison to baseline

Key Learnings

- Occupant preferences alter optimization algorithm and load flexibility impacts
- Compared to WH LF, smaller savings are realized from HVAC LF in the absence of TES and frequent occupant adjustments of thermostat setpoints
- DAC/LI sites offer both challenges and opportunities:
  - Interact manually with the thermostat (turn off / change setpoints)
  - Observed higher tolerance and a wider range of setpoints
- Rule-based algorithm can save peak electric energy and demand

Outdoor unit capable of multiple operation modes

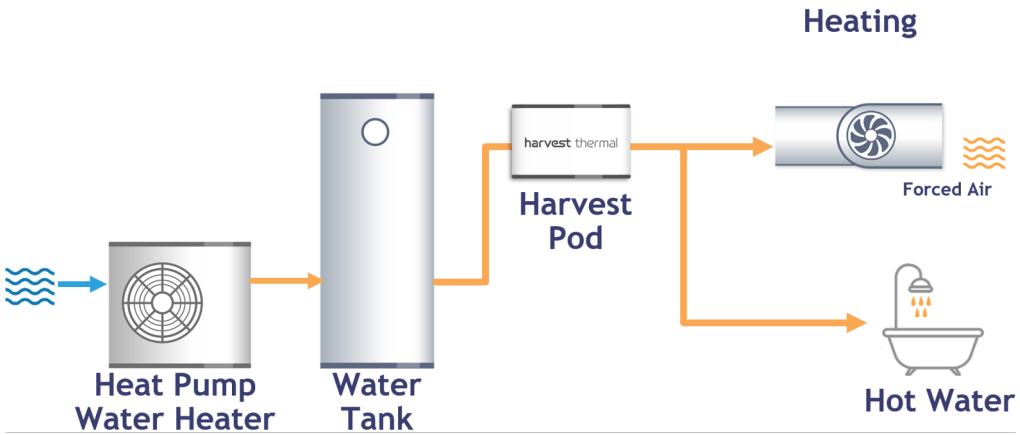
Attic air-handler

DHW tank

Aquastat

- Commercialization of LF technology in partnership with:
  - Multi-function integrated HP manufacturers
  - Home energy management system developers

Residential Space and Hot Water Heating With Integrated Heat Pump + Thermal Energy Storage



harvest thermal

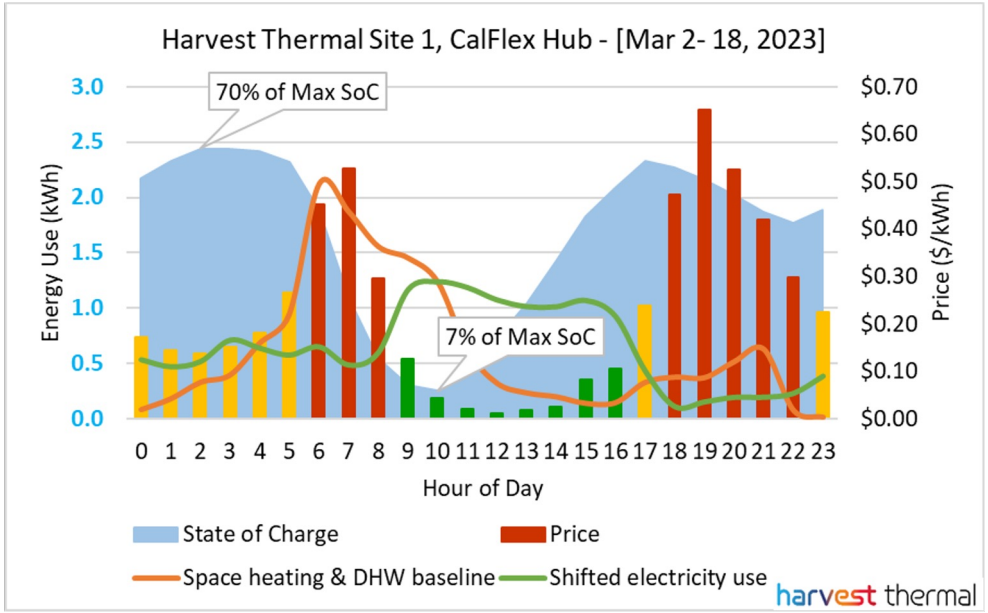
Test Sites:

4 Bay Area homes with existing Harvest Thermal systems

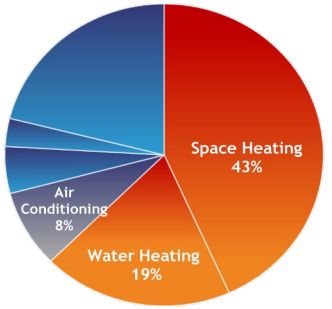
- March 2023: 2 sites, 14 days
- June 2023: 2 sites, 14 days

Sector/Building Type	Residential Single Family
Technology & End Use	Heating + hot water + thermal energy storage
Communications Pathway	Customer Internet ⇨ Harvest Pod ⇨ heat pump and air handler
Expected Grid Benefit	Twice daily load shifting to integrate renewables, mitigate the ramp, and shave morning and evening demand peaks
Testing Status (Timeline)	Tested Two-Peak signal in March 2023 (2 sites) and May 2023 (2 sites)

Test Results



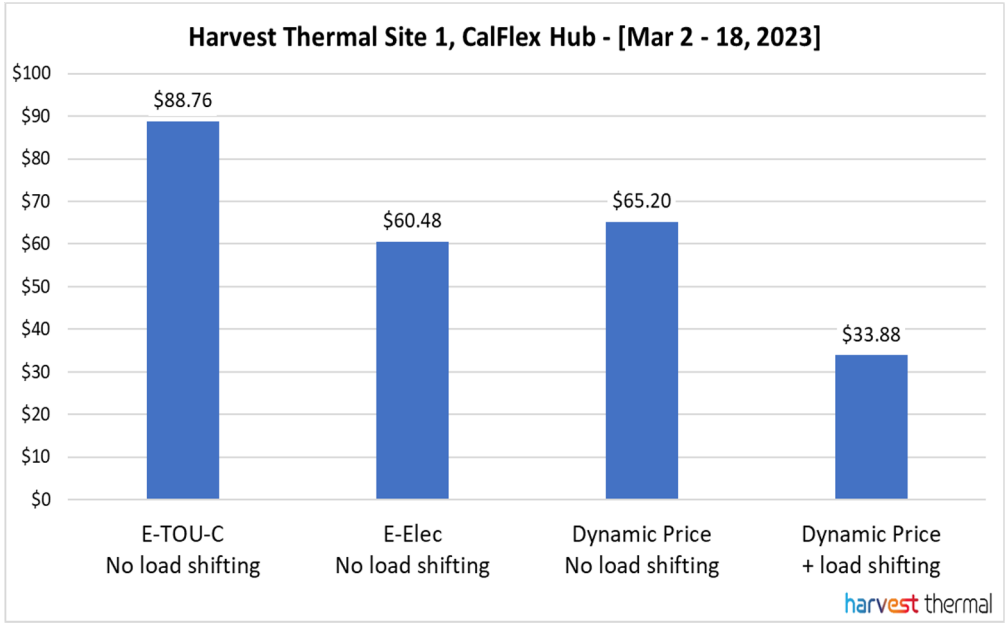
Making two-thirds of home energy use flexible



- **58%** to **80%** of heating + DHW load shifted off-peak
- No impact to customer comfort or convenience
- Harvest controls + thermal storage do all the load shifting work in the background

	Home 1	Home 2	Home 3	Home 4
Heating and DHW Load Shifted Off-Peak	61%	80%	64%	58%

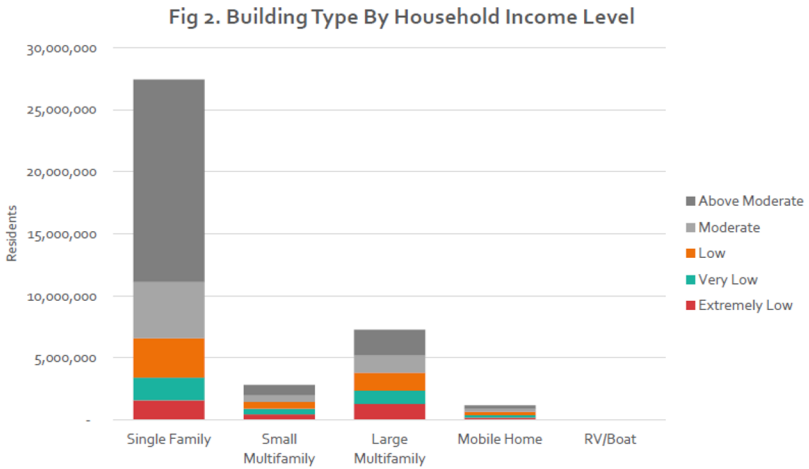
Test Results (Cont'd)



- Dynamic price + load shifting have the potential to reduce heating + hot water energy costs by **50%** of more
- Key factor for equitable building decarbonization

Key Learnings

- Low-income households are split roughly **50/50** between **single** and **multifamily**
- Both housing types are critical for equitable outcomes



NRDC, Housing Equity and Decarbonization in California, 2020

1. The field test **validated the feasibility and benefits** of making residential heating and hot water flexible via dynamic prices

2. **Load flex adoption** requires underlying technologies to be eligible for incentive programs:
   - Thermal energy storage
   - Air-to-water heat pumps
   - Combined heating + hot water

3. **Equitable adoption** requires low-income programs (EBD, ESA, WAP, etc) to encourage adoption of load flex-capable solutions in underserved communities

Ecobee Smart Thermostats Respond to Dynamic Prices

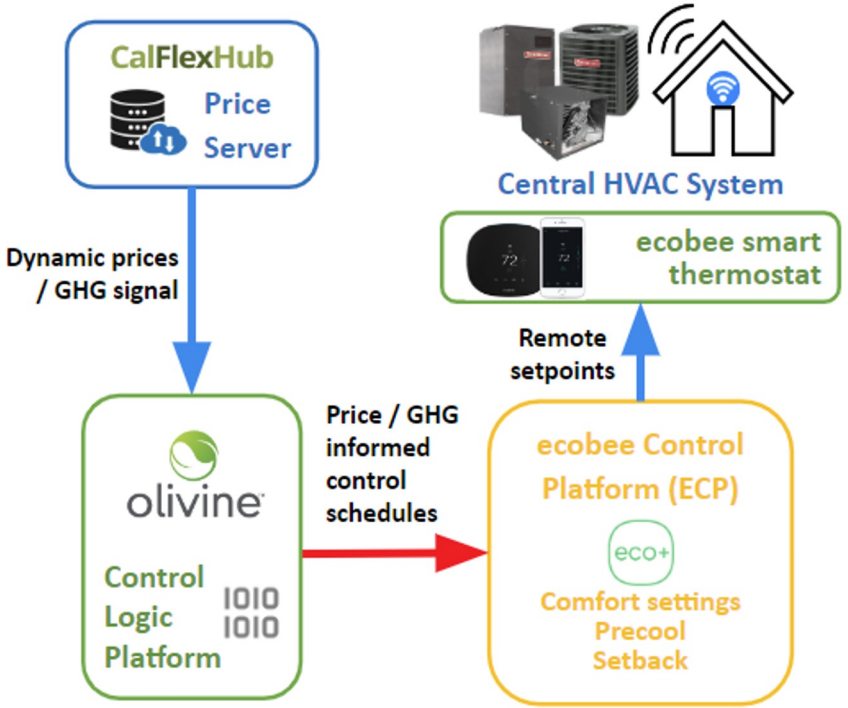
Test Sites:

- 20 single family homes and townhomes in Fresno and other locations with central HVAC
- 13 households in DAC and 3 households in LI area.

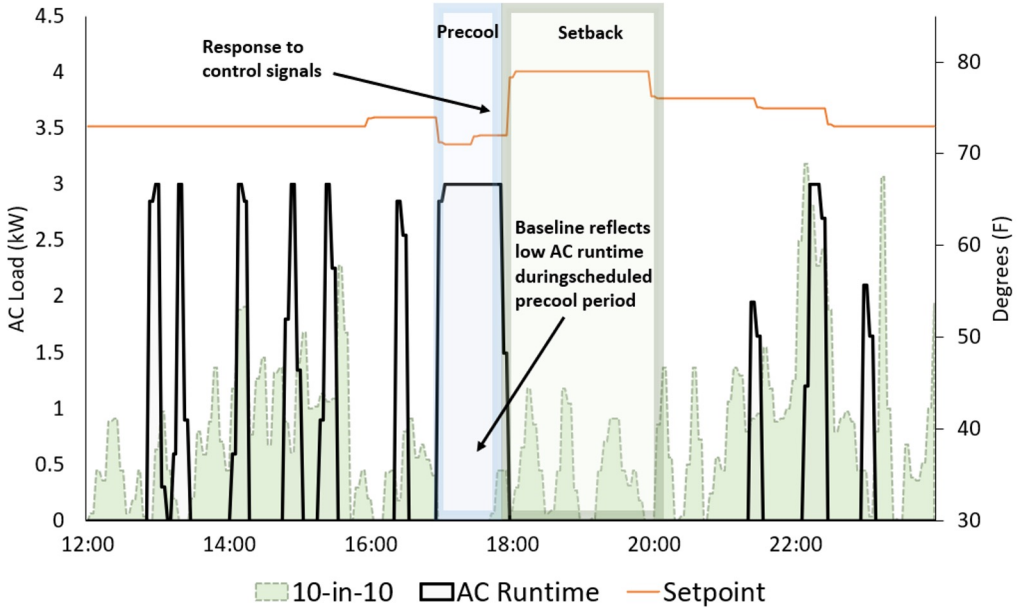
Sector/Building Type	Residential; SF homes
Technology & End Use	Smart Thermostat; HVAC
Communications Pathway	3rd party (Olivine) cloud -> OEM cloud -> thermostat -> AC or HP
Expected Grid Benefit	Current summer peak + emergency reliability and future winter peak
Testing Status (Timeline)	Feb 2023 (heating), May 2023 (cooling, spring price/GHG), Sept 2023 (cooling, summer price)

Communication Architecture

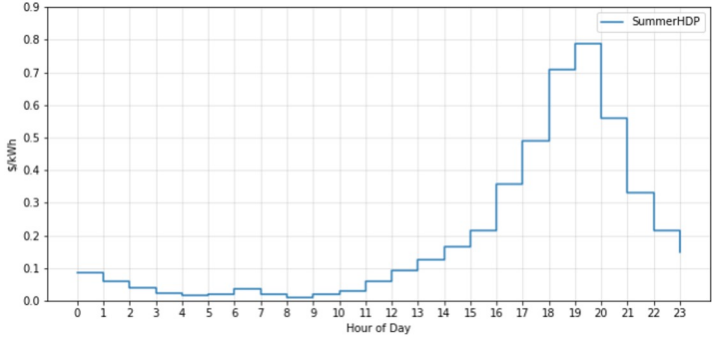
- Day-ahead 24-hour dynamic price or GHG signal retrieved
- Dynamic-price and/or GHG signal informed control logic
- Olivine cloud-to-ecobee cloud dispatched customer setpoint changes



Field Test #3: Summer Test



- A device with an automated TOU setpoint schedule tends to be more responsive to control signals
- Delivery of ~1.6 kWh for a 2-hour setback period. ~$2.5 of direct bill savings per the dynamic rate



CalFlexHub SummerHDP Rate Profile

Key Learnings

- At current participation levels, a mostly DAC aggregation of 8,000 smart thermostats could deliver ~1MW of load shed capacity
  - ~0.5 kW power delivered per site, comparable to non-DAC aggregations
  - ~25% successful load response, opportunity to increase load available for shed
  - Most DAC and LI participants still operate smart thermostats manually
- Scaling Opportunities and Challenges
  - Education and training at time of installation to increase response rate
  - Reduce participant acquisition cost through targeted marketing, streamlined enrollment process, and incentives

	Load Response	Signal Comm. Issues	No Cooling Load
Disadvantage Community (DAC) 13 sites	5%	45%	15%
Low Income (LI) 3 sites	10%	0%	5%
Non-DAC/LI 4 sites	8%	12%	0%

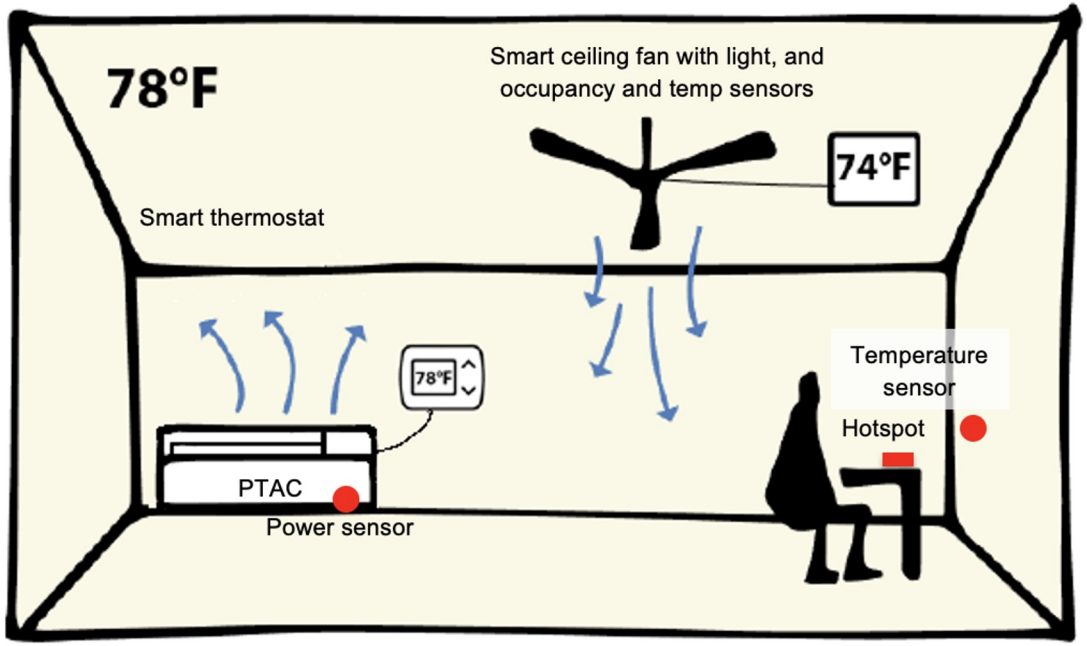
Load Response: Received both precool and setback control signals and AC responded.

Signal Issues: Did not receive one or both precool and setback signals.

No Cooling Load: Received both precool and setback control signals but setpoint was too high or the thermostat was in OFF mode.

CoolFIT: Fan Integrated with Thermostats

Test Site: Franco Senior Center, Stockton

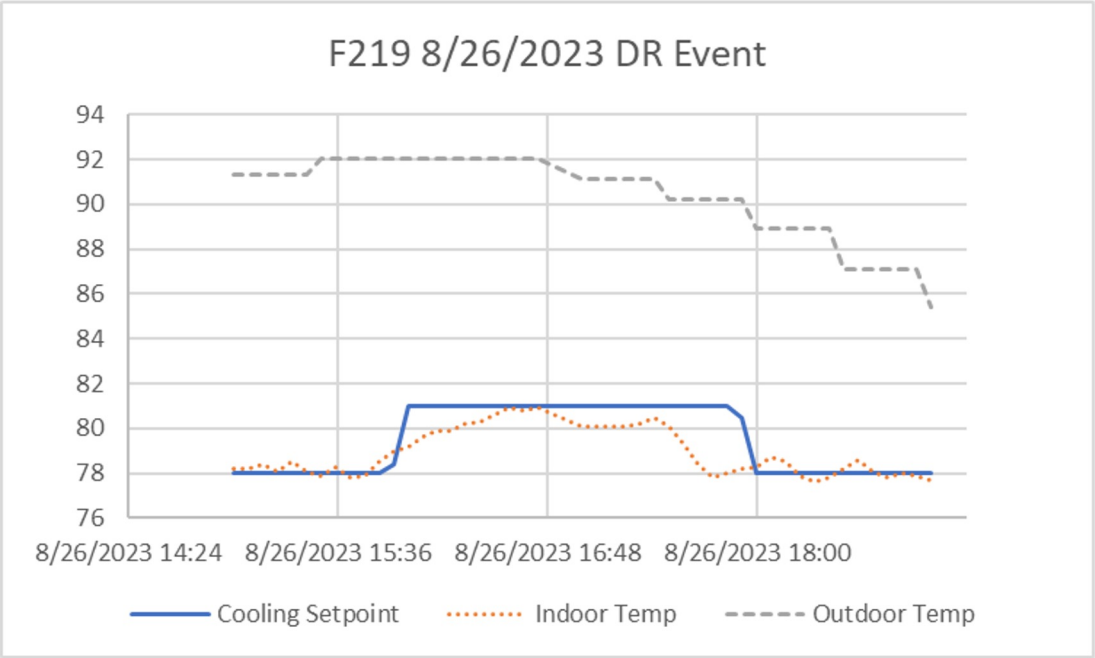


Sector/Building Type	Residential Multi-family, DAC
Technology & End Use	Smart ceiling fan, smart thermostat, HVAC (Packaged Terminal AC)
Communications Pathway	Research cloud => OEM clouds => fan and thermostat to PTAC
Expected Grid Benefit	Load shed, load shift
Testing Status (Timeline)	Conducted several tests: 1F, 2F, 4F over 1h, 2h, 3h and surveyed 5 residents for comfort

Test Method

- Installed smart thermostats on PTAC units in five apartments
- Installed power and temperature monitoring equipment and hot spot
- Interviewed five residents about comfort, thermostat and fan use

Test Results



Duration 16:00 - 18:00
Temperature - 3 °F higher than a baseline of 78 °F
Response to Comfort Survey: Comfortable

- 20 events
- Raised the temperature of the thermostats (1-4F) for 1-3 hours
- Fans responded
- Surveys indicate residents remained comfortable (49 of 52 “comfortable”)
- Still analyzing data

Key Learnings

- One can add a smart thermostat to an existing Packaged Terminal Air Conditioner!
- Fan kept people comfortable and enabled HVAC energy savings
- Need senior-friendly thermostats with larger text and icons
- Remote control more convenient
- Potential for battery-powered fan
- Exploring smart wall switch for other brands of ceiling fans

GRID Alternatives' mission is to build community-powered solutions to advance economic and environmental justice through renewable energy.

We envision a rapid, equitable transition to a world powered by renewable energy that benefits everyone.

The nation's largest low-income dedicated renewable energy developer, installer and workforce development organization.

<u>Load Flexibility – Potential</u>

- CalFlexHub Equity Advisory
- Non-Profit Collaborative Partner
- Program Administration
- Marketing, Education & Outreach
- Job Training
- Policy Advocate

People. Planet. Employment.

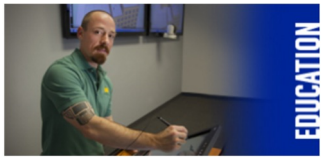
Engagement Practices for Equitable Adoption of New Technology

- LISTEN
- Engage as partner in communities, with existing organizations, long term relationships, build trust
- Actively provide accessible information through trusted and familiar channels, languages, cultures
- Use plain language, NOT industry jargon
- Design for actual usability
- Address connectivity & integration; Don’t assume
- Guarantee sufficient benefits
- Plan for operations & maintenance
- Support and accommodate engagement (food, childcare, appropriate timing and location, access, transportation, funds for time)

ASSOCIATION FOR ENERGY AFFORDABILITY INC.

Energy Efficiency is our Specialty, Affordable Housing is our Priority

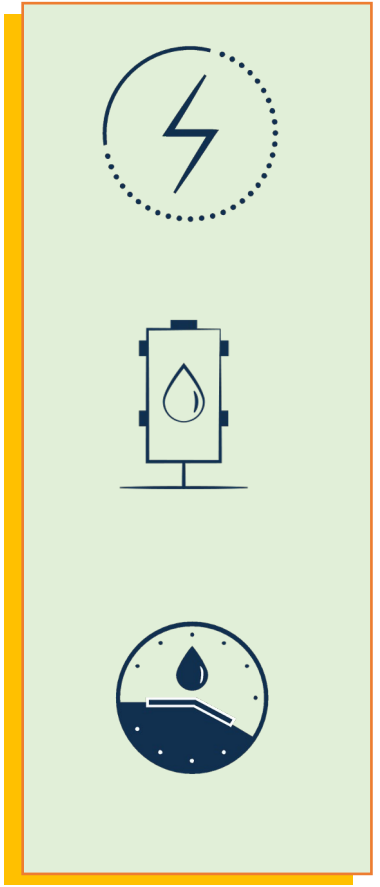
The Association for Energy Affordability, Inc. is dedicated to achieving energy efficiency and decarbonization in new and existing buildings in order to foster and maintain affordable and healthy housing and communities, especially those of low-income. With locations in CA and NY, AEA representatives engage in a broad range of educational, technical and construction management activities and services to promote this mission and develop the industry that advances and sustains it.



- Energy efficiency program design and implementation
- Energy research & demonstration projects
- Energy audits and green building design for new construction and existing buildings
- Electrification: Currently provide numerous California multifamily electrification programs, as well as direct consulting to buildings on electrification best practices
- Load Shifting: PG&E WatterSaver, SGIP-HPWH (TECH), CEC EPIC R&D

Importance of Load Flexibility and Best Practices

- Reduce Utility Bill Costs
- Identify flexible loads but don’t penalize for inflexible loads
- Simple connectivity requirements for residential occupants (WiFi can be unreliable or nonexistent)
- Ideally set and forget with no impact on comfort, easy to enroll and participate
- Reliability and predictability, not always a one-size-fits-all
- Acknowledge “big-brother” concerns



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