Building to Grid:

Thermostats to Microgrid

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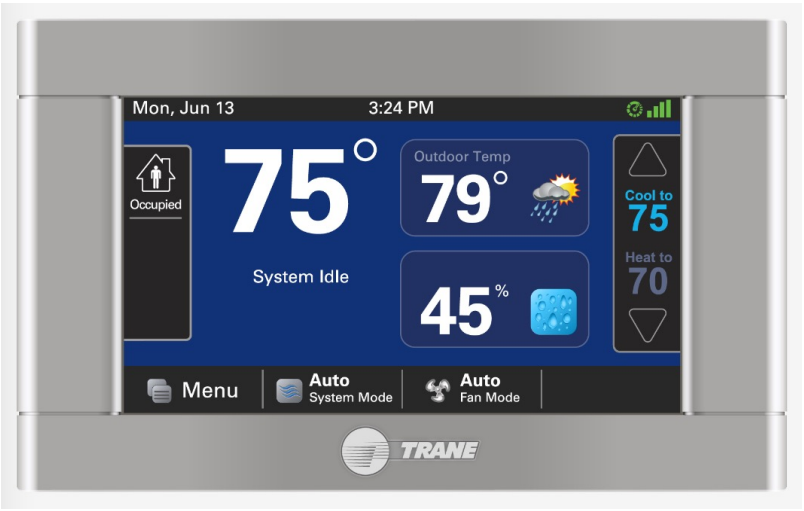
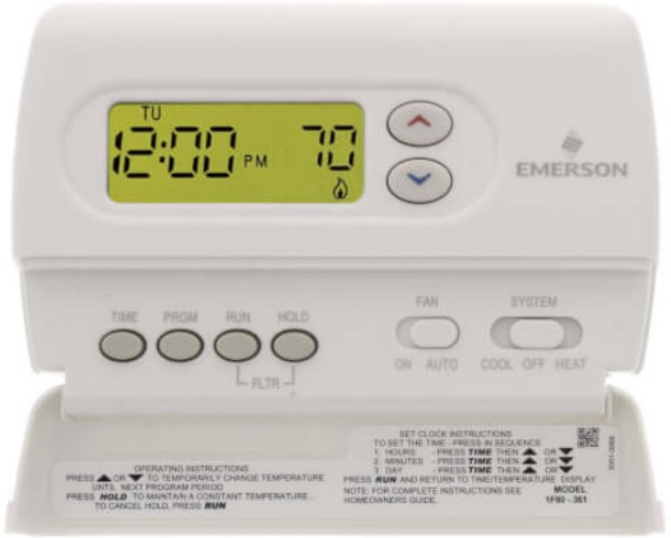
Cal Plug Workshop
17 April 2023

Why study thermostats?

Rebuilding Together®

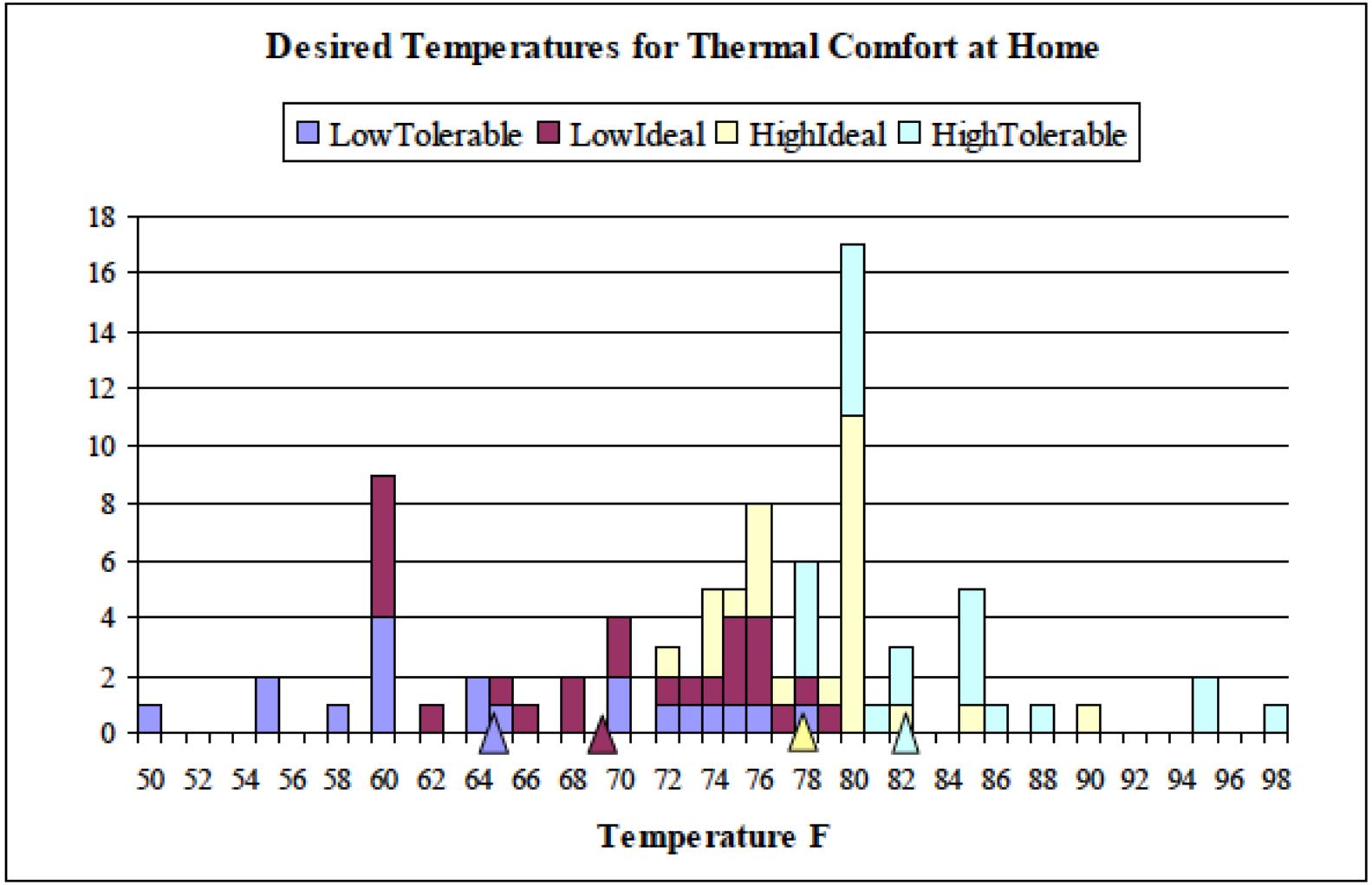
Thermostat design





Thermal comfort

At what temperatures are you comfortable?



Usability

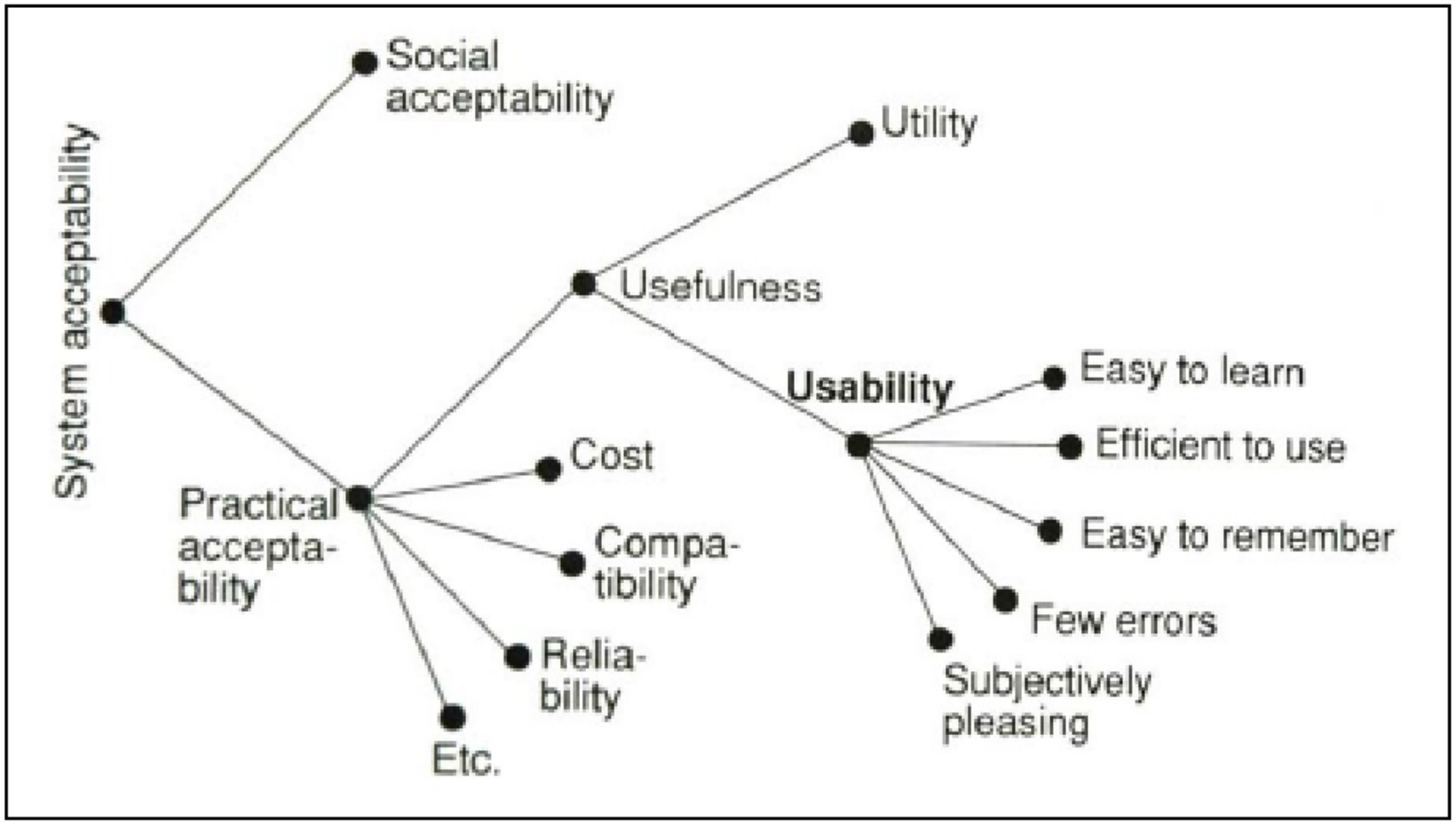


Figure 25: Model for system acceptability (Nielsen, 1993).

Usability test

- Usability test of 5 thermostat
- 31 subjects
- 7 tasks

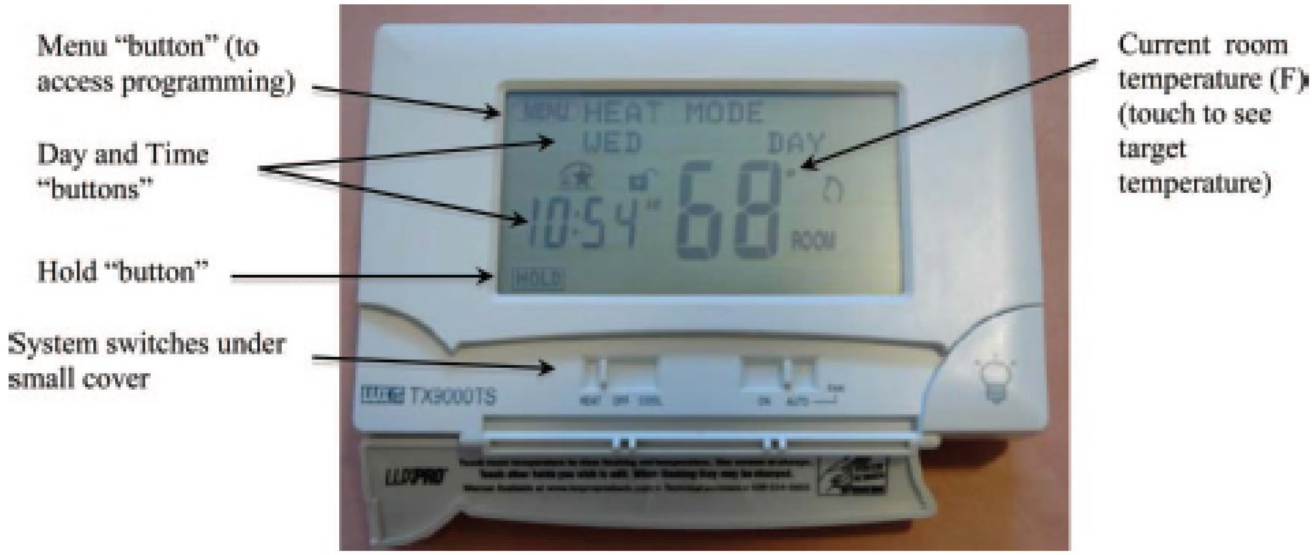
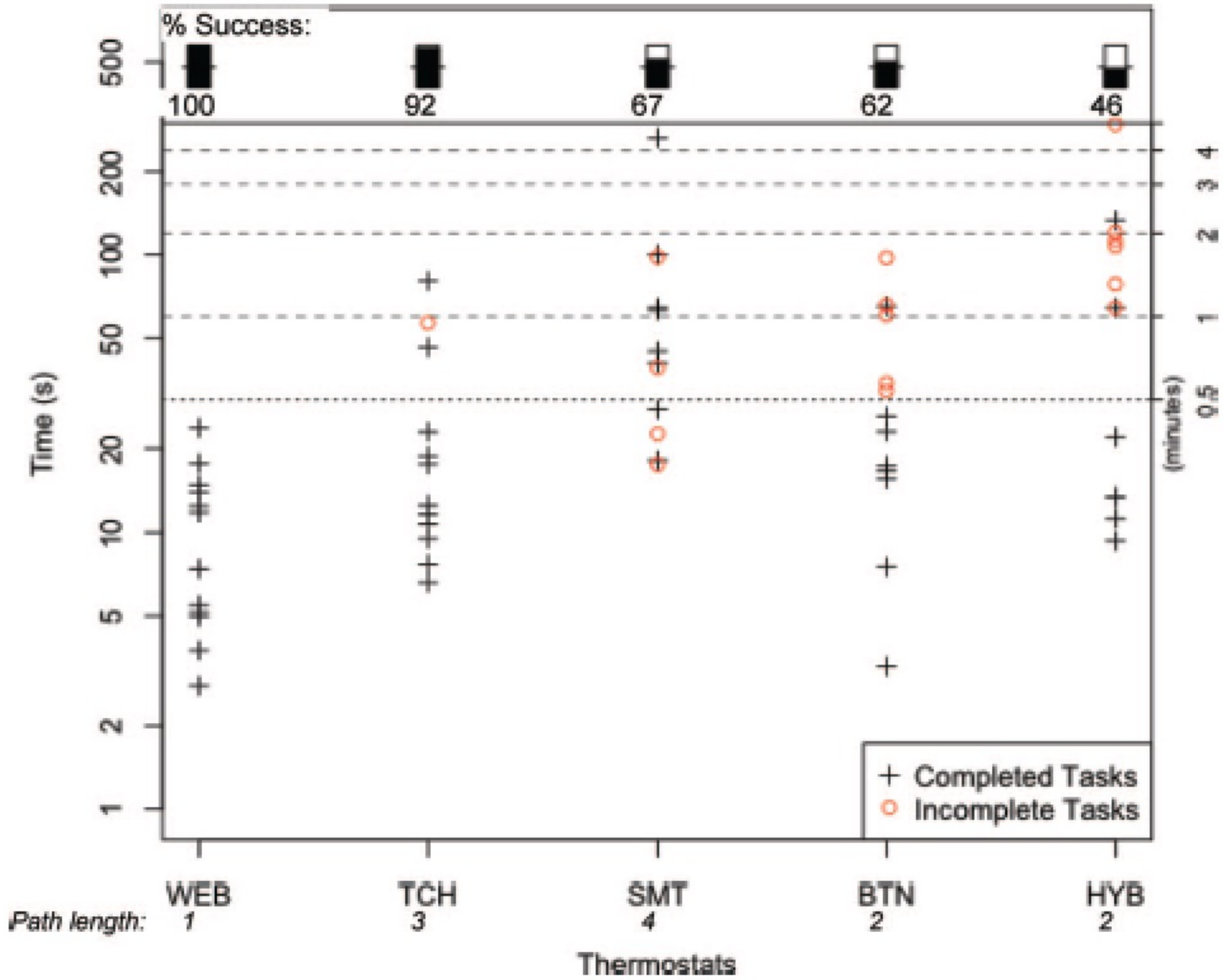


Table 4. Description of tasks.

Tasks	Description
Set heat	Set the thermostat to HEAT mode. (Setting was OFF at the start of the task).
Set time and day*#	Set the thermostat to the current day and time. (The time settings were programmed to Monday at 12:00 am for the start of the task.)
Current setting	Identify and read aloud the temperature that the thermostat was set to reach at that current time.
Future setting	Identify and read aloud the temperature that the thermostat was set to reach at a future period (Thursday at 9 pm). (No need to change any settings).
Vacation/away/hold	Set the thermostat to maintain the same temperature during a five-day period when one is away.

Note: *not performed on the WEB because time settings could not be modified. #setting the day not performed for the TCH because this required a code from the manual.

Usability



Time on task, success rate, and ideal path length for Task 1: Set to heat.

Heuristic evaluation

Heuristic	Honeywell 	Trane 	Emerson Sensi 	Johnson Controls 	Carrier 	Google Nest 	Pelican 	Ecobee 	NT 
Visibility of available options (home)	Only current temp + heat mode + menu	Typical + hold	Words + icons	Can't turn off from Home screen	Only temp/fan icons, home icon	Can't easily turn off	Typical words	Icons	Text (small), Icon
A wide and shallow decision tree	Not easy to find "set time/day"	Many choices	Two deep	Too deep	Must scroll thru 15 icons (6 at a time)	Need to scroll through many choices	*Only Tasks 1 and 3 accomplished with wall interface*	Menu screen	Poor for setting time/day
Navigation cues	Done, Back, but lots of scrolling required	Done, Back, Apply	Back arrow visible	Pull down menu, Scroll dots, right/left arrow swipe	Home icon with two dots left and right—very clear	Linear scroll through choices, easy to get lost		Menu and arrows	Check marks, back arrow, up/down
Clear hierarchy of display	Large display of current temp	Large display of current temp	Large display of current temp	Large display of current temp	Large display of current temp	Large display of setpoint but not current temp	Large display of current temp	Large display of current temp	Large display of current temp
Consistency and standards	Terms, icons, orange/blue colors	Terms, icons, orange/blue colors	Terms, icons, orange/blue colors	Ok, Terms, some icons	Icons, colors, means of setting day/time	Terms, icons, orange/blue colors	Up/down arrows	Terms, icons, colors; color of icon very subtle	Icons not standard but intuitive; requires toggling
Natural mappings	Menu icon, "heating to" text; hold until text	Touch and hold is not easy to use	Not easy to change temperature in auto mode	Two settings have same icon	Touch scroll not easy to use	Target temp shown only at beginning of period		Clean menu navigation	Unclear when icon is a touch button or reflecting state
Error prevention and recovery	No Save or Confirm; information icon	Text explanation of choices; small arrow buttons;	Ok. Cancel, Save.	Done, Cancel	Several ways to access some features	Done		Text explanation	Flashing in set mode
Feedback from controls	Touch scroll difficult to control	Ok	Ok	Not easy to swipe and scroll	Audible chirp when making selection; sometimes push buttons nonresponsive	Turn knob to scroll and push knob to select		Touchscreen, menu bar, arrow selection	No color feedback

Thermostat takeaways

- Can help save energy, reduce peak loads, keep the lights on
  - both houses and small commercial buildings
- Thermal comfort varies (with season, outdoor temp, activities)
- Usability is important and we have ways of evaluating this
- Good control design includes the human—more satisfied people
  - Provide information that enables insight and provide a means influence
- One size does not fit all
- Calibrate your sensors

Oakland EcoBlock: A Zero Net Energy Neighborhood Retrofit

California Energy Commission Advanced Energy Community project

- Phase I (2015 – 2018), $1.5M + donors
- Phase II (2019-2024), $5M + donors + cost share

Unique features:

Retrofits of older housing stock, combining energy efficiency with electrification, water efficiency, EV car share, and (we hope) a solar microgrid

Community financing, ownership and management via nonprofit Association with fees

Oakland EcoBlock: affordable, clean, resilient energy

Energy efficiency + electrification retrofits on older urban housing stock

Rooftop **solar** and central battery for a microgrid

Stormwater mitigation and water efficiency

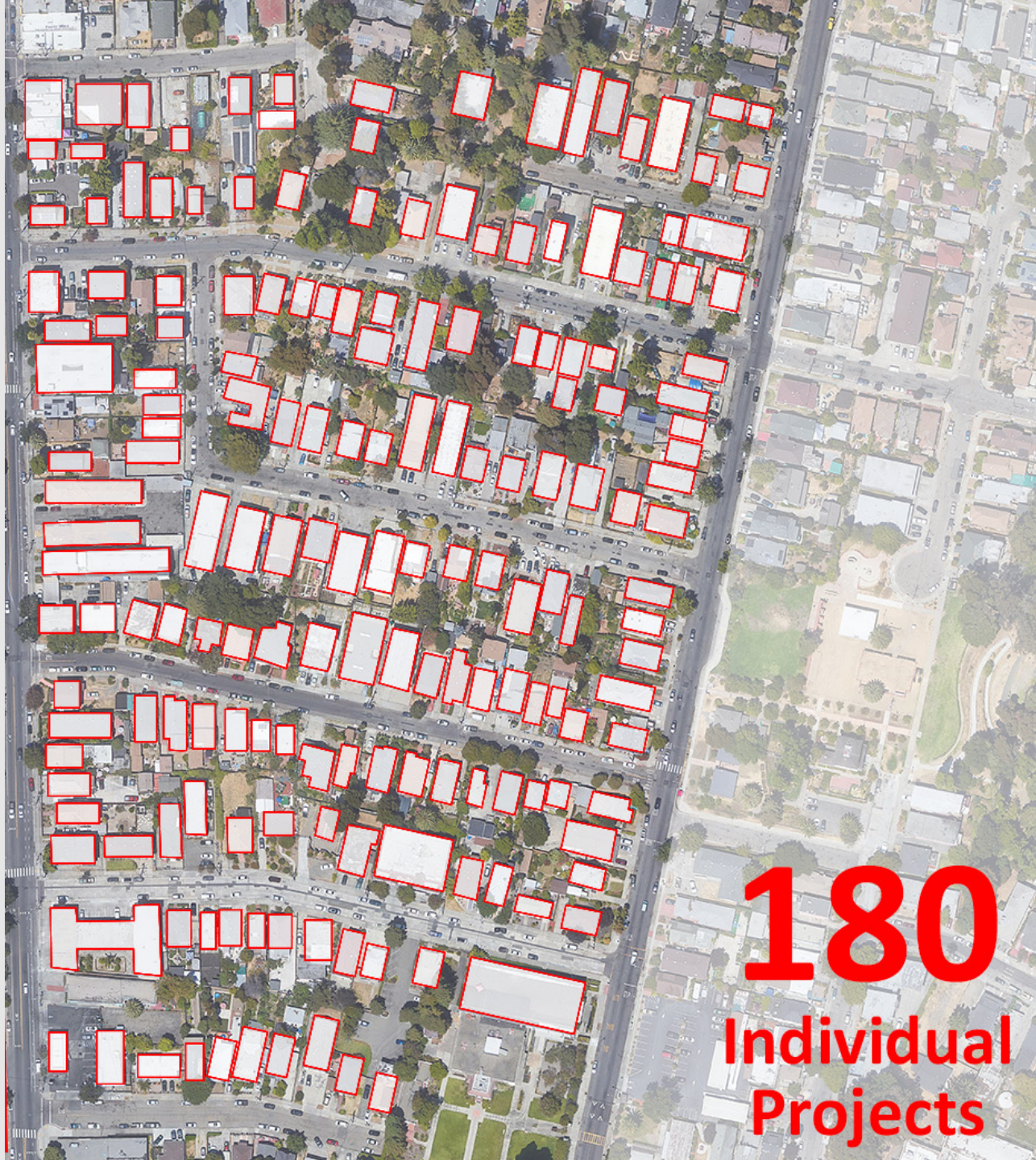
Curbside **EV charger** and **EV car share**

Innovative legal & financial structures for **community ownership & governance**

Provide templates and best practices for a **path to scale**

Multi-customer microgrid retrofit with urban SF/MF

Retrofitting homes typically happens one at a time….



We think EcoBlock can reduce the time, effort, and materials for retrofitting urban neighborhoods

180
Individual
Projects

We are exploring how EcoBlock leverages Economies of Scale to

- Reduce capacity for solar/storage by sharing
- Reduce energy transmission losses
- Save construction time
- Fewer vehicles through car share
- Decommission natural gas lines
- Rapidly increase adopters through neighbor/peer effect

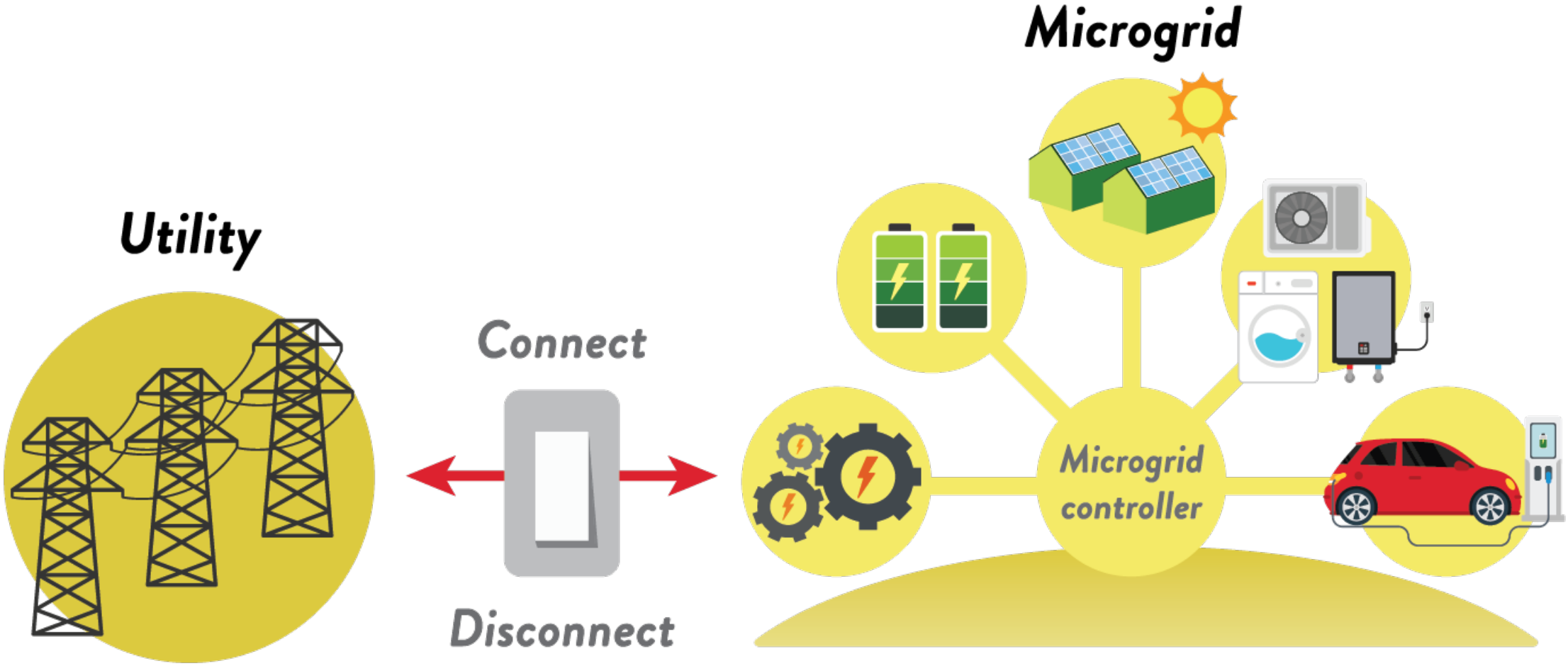
180
Individual
Projects

Economies of Scale: Neighbor or Peer Effect

- Solar adoption is contagious in neighborhoods regardless of income.
- These new technologies-–heat pumps, induction stoves—are hard to understand
- Trusted source of information: Neighbors talk to each other about new technologies and can reduce the burden
- Potentially reduces soft costs of acquiring customers (home performance, electrification, solar)

Illustration: Thoka Maer

What is a Microgrid?

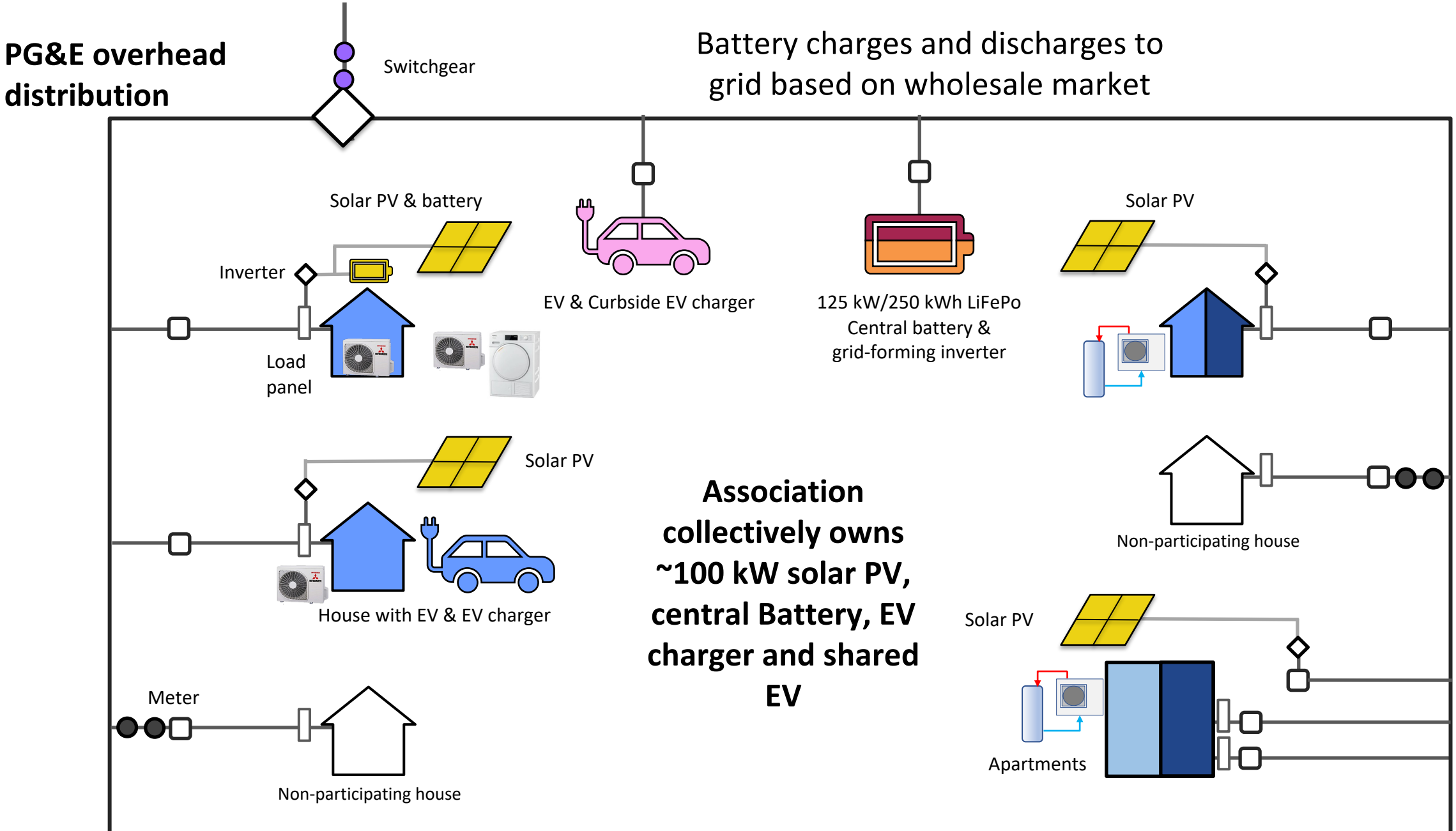


An islandable distribution circuit section of the utility electric grid

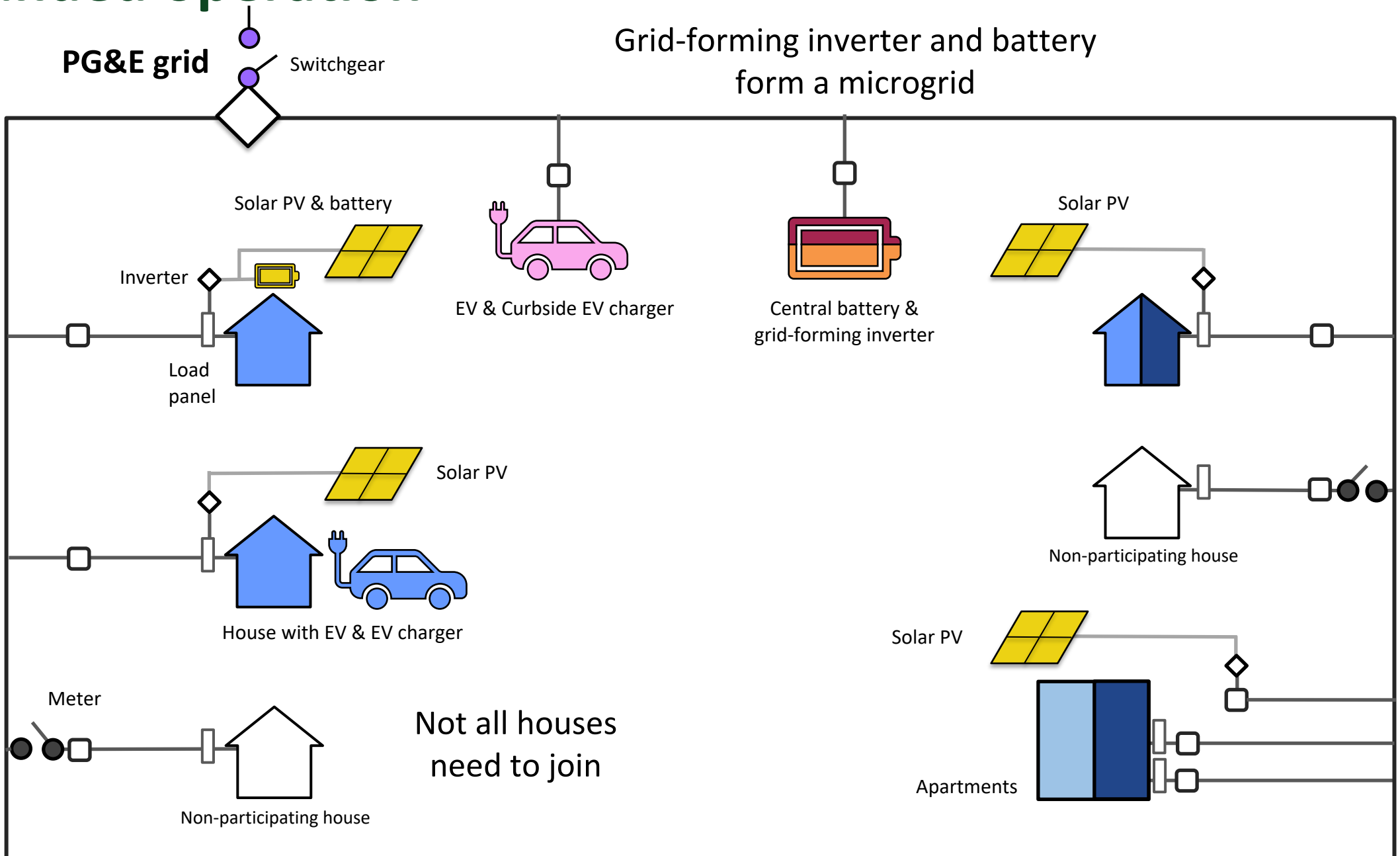
Energy

Microgrid Design

Community Microgrid: Normal operation

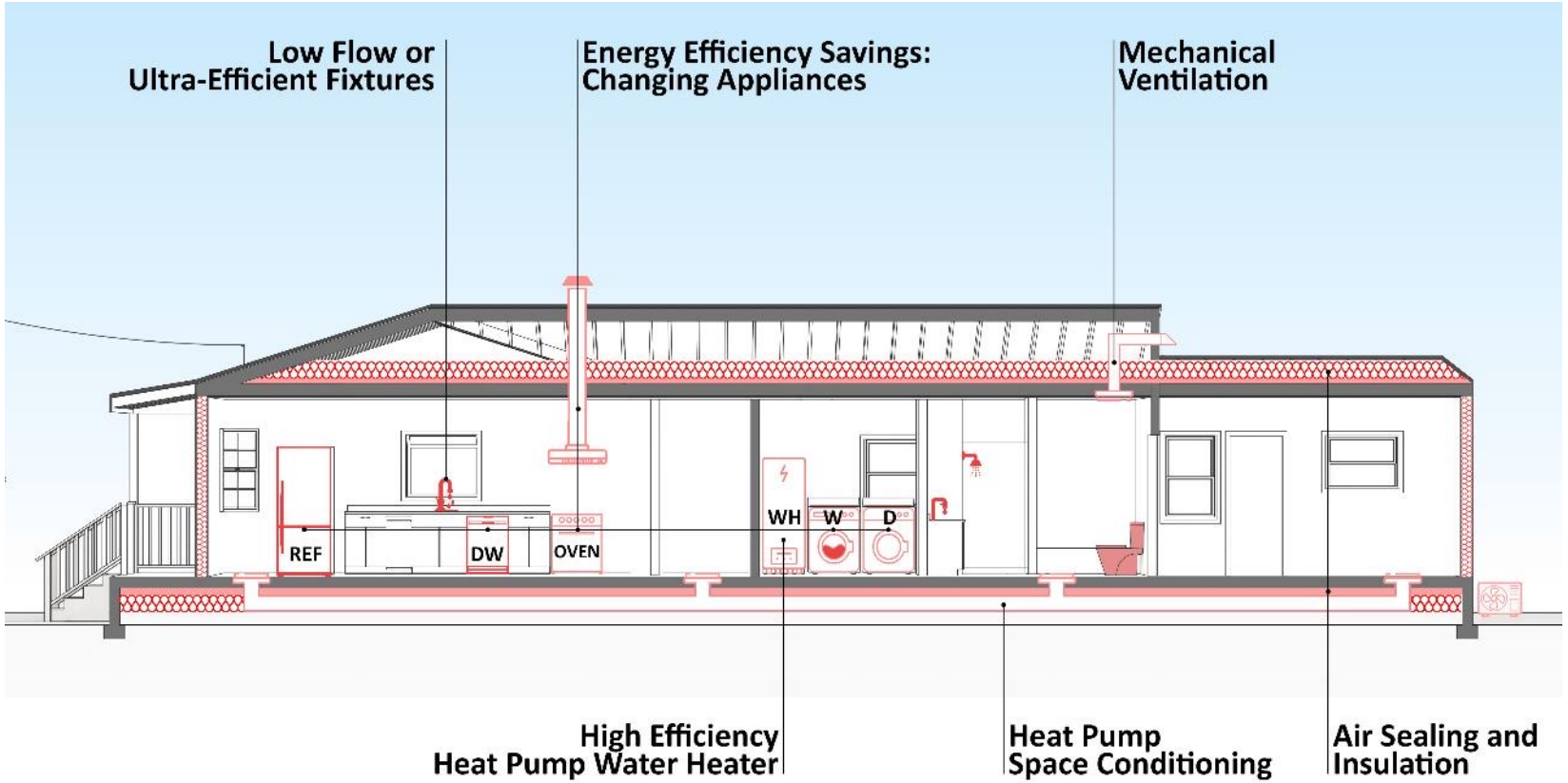


Islanded operation



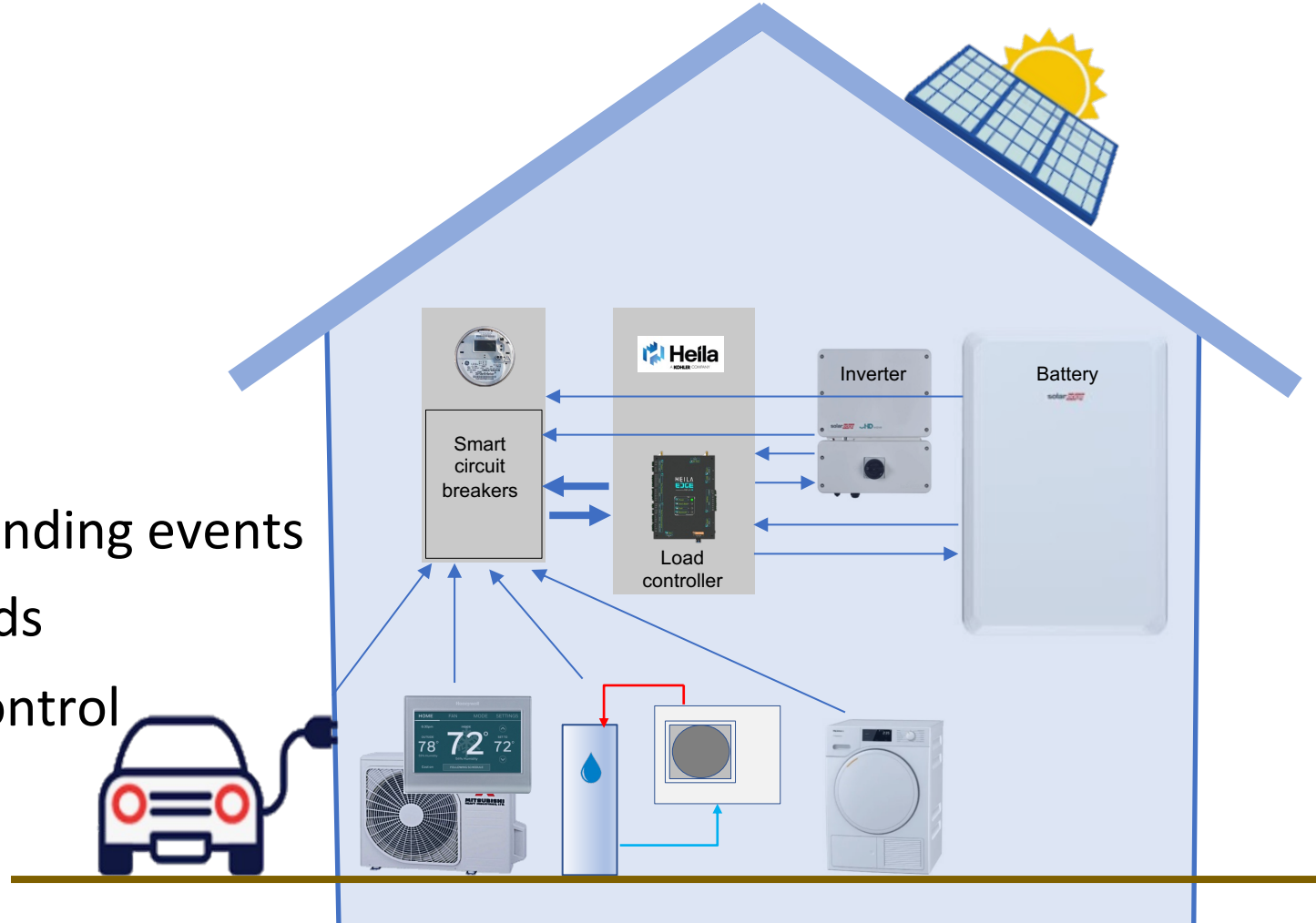
Energy Home-Based Improvements

- Improved **air quality**
  - Remove natural gas service by replacing cooking and heating/water heating appliances
  - Exhaust fans
- Improved **comfort**
  - Air sealing & insulation
  - Heat pump space conditioning (heat/cool)

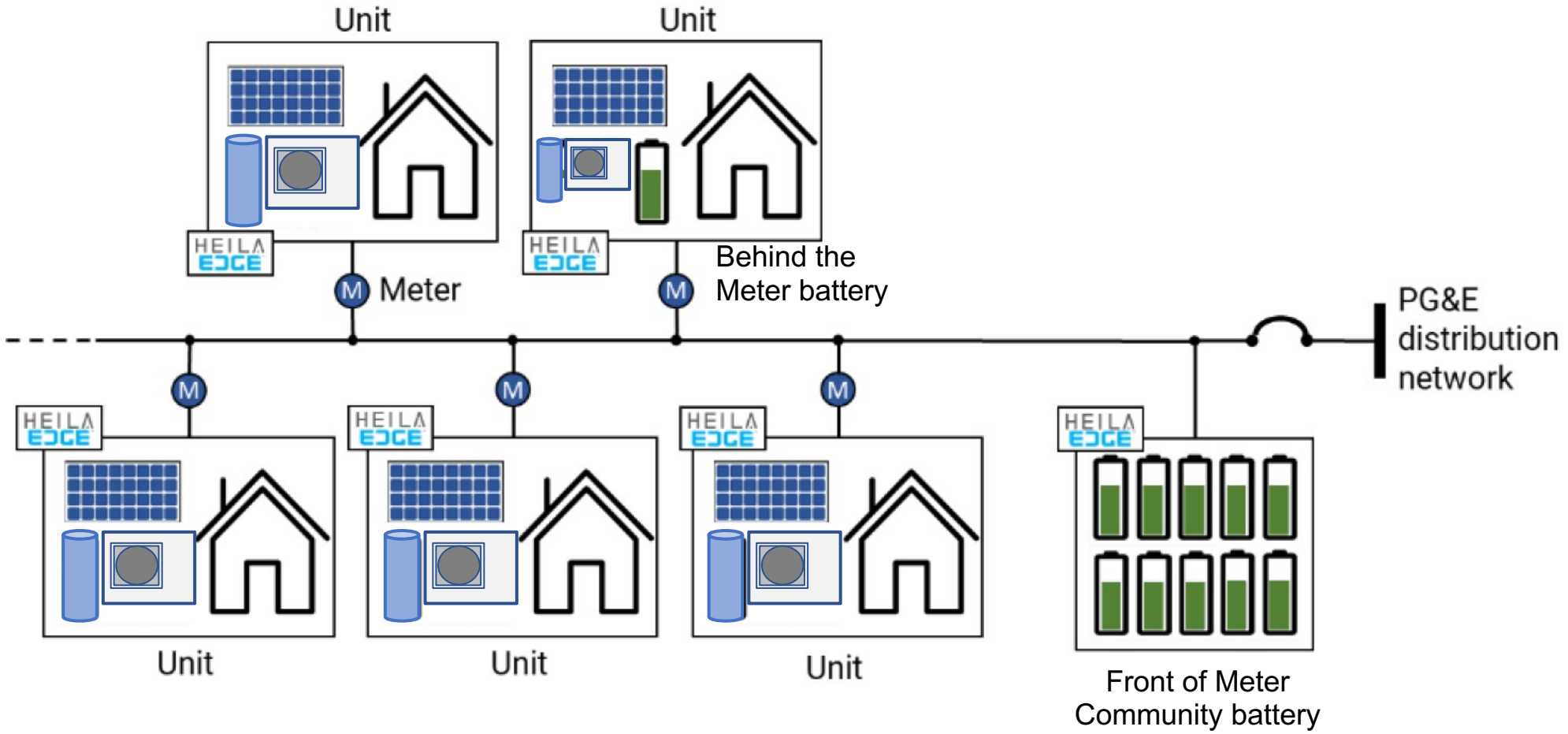


Home Energy Control

- Smart circuit breakers or modules
  - Whole building energy monitoring
  - Solar production
  - Monitor & control major loads
    - Heat pump space conditioning
    - Heat pump water heating
    - Clothes dryers
    - EV charger
- Dynamic critical load selection for islanding events
- Management of daily time-of-use loads
- Microgrid controller as supervisory control



Microgrid Control



Mobility

- **Curbside EV charger:** one charger with option to add more in the future
- **EV car share** for block participants
- Potential for other e-mobility in the future
- Majority responded they would get rid of a second car if they had access to car share

Water

- Laundry-to-landscape workshop (really helps strengthen community!)
- Block-level stormwater mitigation
- Rainwater collection
- Sidewalk landscaping improvements & tree planting

EcoBlock Research & Implementation Team

Senior Advisor

Energy Team Co-Lead

Postdoctoral Researcher

Senior Advisor

Water Team Co-Lead

Co-Principal Investigator

Research

Principal Investigator

General Counsel

Energy Team Co-Lead

Senior Advisor

Energy

Guidebook Lead

Design/ Construction

Legal

Mobility Lead

Research & Implementation

Sustainability Director, City of Oakland

Community Team Lead

General Contractor

Design/ Construction Team Co-Lead

Water Team Co-Lead

Implementation

Oakland EcoBlock Stakeholders Organizational Chart

Partners

City of Oakland

Technical Advisory Committee

BASSETT | AVOCADO HEIGHTS advanced energy community

ZNE/Alliance

Community

EcoBlock Community Association

ecoblock™

Research & Implementation

Berkeley UNIVERSITY OF CALIFORNIA

ciee California Institute for Energy and Environment

CITRIS BANATAO INSTITUTE

Renewable & Appropriate Energy Laboratory RAEL

BERKELEY LAB

tsrc

SUN LIGHT & POWER

one OAKLAND NEIGHBORS FOR EQUITY

INTEGRAL GROUP

Heila

ECO PERFORMANCE BUILDERS

CDL CIVIC DESIGN LAB

SIEGEL & STRAIN Architects

SmartBlock communities

DTA DAVID TAUSSIG & ASSOCIATES

PERKINSCOIE

MIG

ASSOCIATION FOR ENERGY AFFORDABILITY

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MGL Microgrid Labs More than renewable energy

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EAST BAY COMMUNITY ENERGY

EBMUD

The Oakland EcoBlock prototype

- Provides energy retrofits to make houses more comfortable
- Lets the community own their source of clean energy
- Keeps the lights on during the next power outage
- Improves local and indoor air quality
- Provides access to an Electric Vehicle car share and local EV charging
- Reduces water costs
- Reduces stormwater runoff

Image credit: People Power Solar Collective

ecoblock™

ecoblock.berkeley.edu

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