Grid Interactive Efficient Buildings: Technology, DR Potential and CalFlexHub

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Presentation Outline

1. **Building Research at Lawrence Berkeley National Laboratory**
2. **Grid Interactive Efficient Buildings**
3. **GEBs and the Potential For Demand Response in California**
4. **The California Load Flexibility and Deployment Hub, CalFlexHub**
5. **Summary and Future Directions**

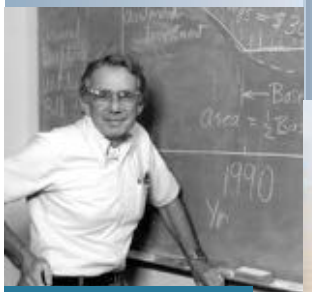
1. Issues Motivating Advanced Buildings Technologies

Oil Embargo | Indoor Health | Urbanization | Changing Electric Grid | Climate Change | Equity Energy and Environmental Justice

TIME

Highlights and Accomplishments

Oil Embargo	Indoor Health	Urbanization	Changing Electric Grid	Climate Change	Equity Energy and Environmental Justice

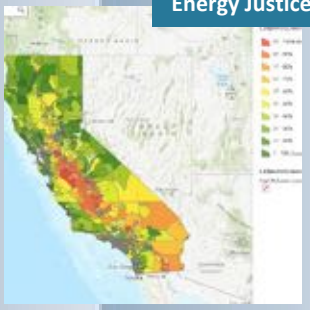


Energy Efficiency Enter Mainstream

Healthy Building Systems

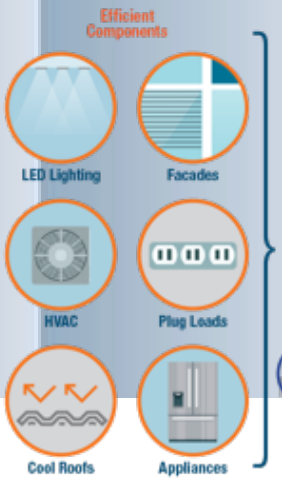
Smart Analytics and Integrated Controls

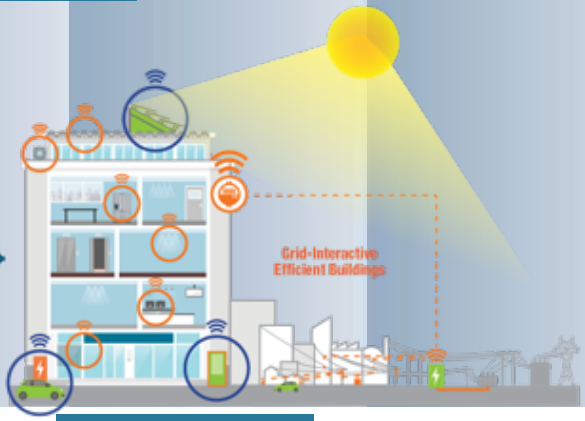
Urban Science



Resilience and Energy Justice

Energy Efficiency Brings Cost Savings





Grid Interactive Efficient Buildings

Connected Communities

2. Why We Need Grid Interactive Efficient Buildings

Integrate the growing share of variable renewable energy

Reduce costs to replacing aging electricity system infrastructure and improve system reliability

Assist in achieving decarbonization goals through reduced fossil fuel generation and increased heating electrification

Optimize energy use based on customer preferences

FLEXIBLE BUILDING LOADS CAN BENEFIT OWNERS, OCCUPANTS, AND THE ELECTRIC GRID

GEBs are Characterized by Active, Continuous, and Integrated Energy Use

EFFICIENT

Persistent low energy use minimizes demand on grid resources and infrastructure

CONNECTED

Two-way communication with flexible technologies, the grid, and occupants

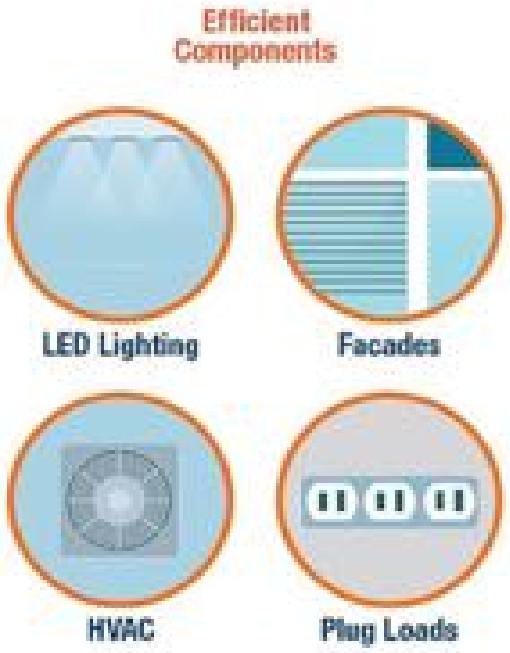
SMART

Analytics supported by sensors and controls co-optimize efficiency, flexibility, and occupant preferences

FLEXIBLE

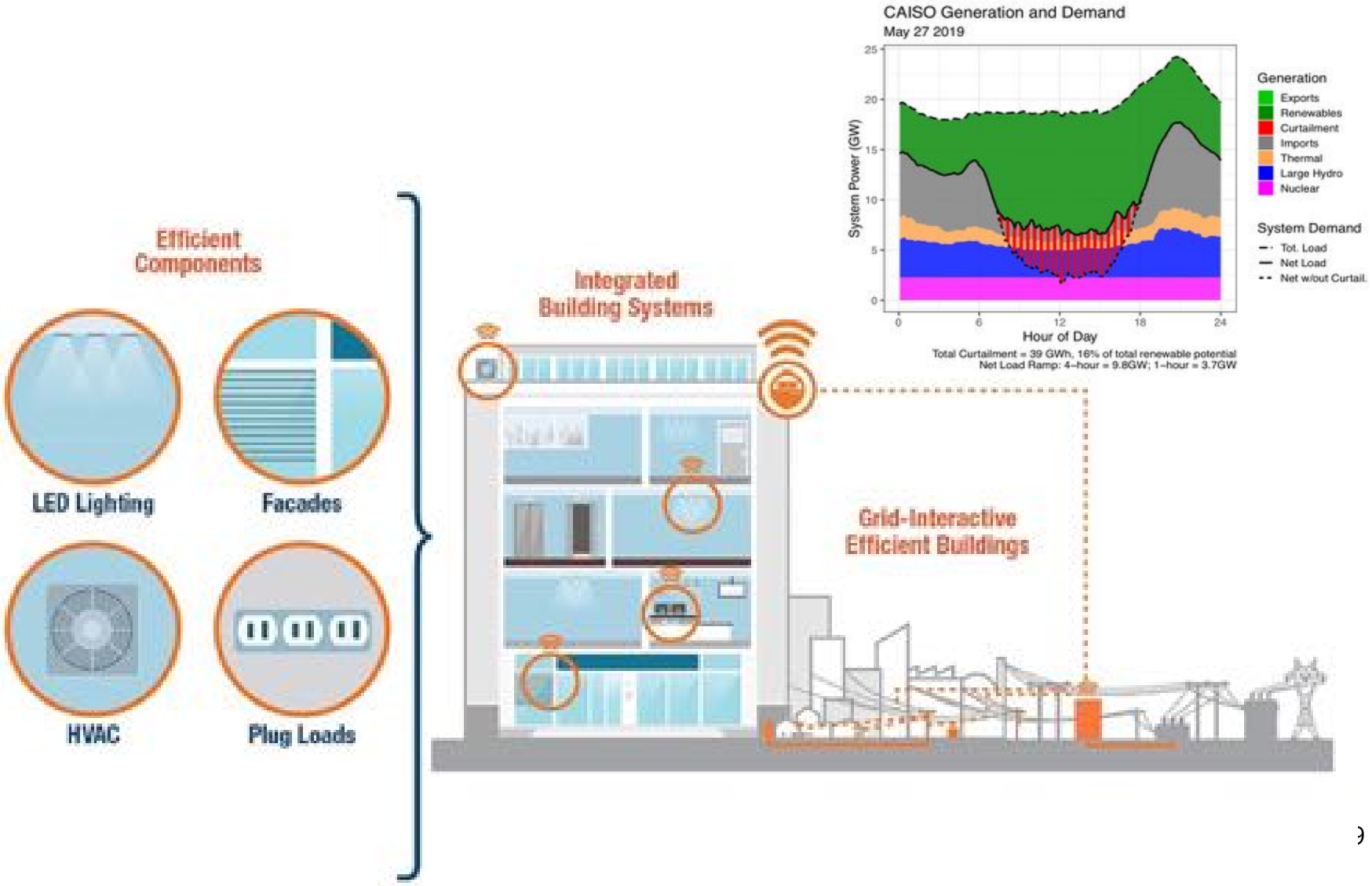
Flexible loads and distributed generation/ storage can be sued to reduce, shift, or modulate energy use

Grid Interactive Efficient Buildings Use Efficient Devices

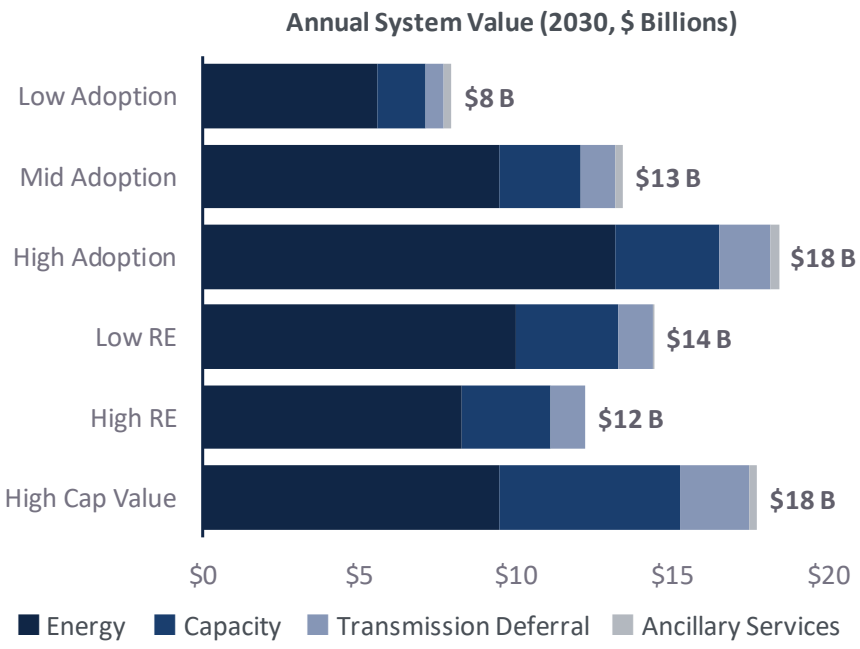


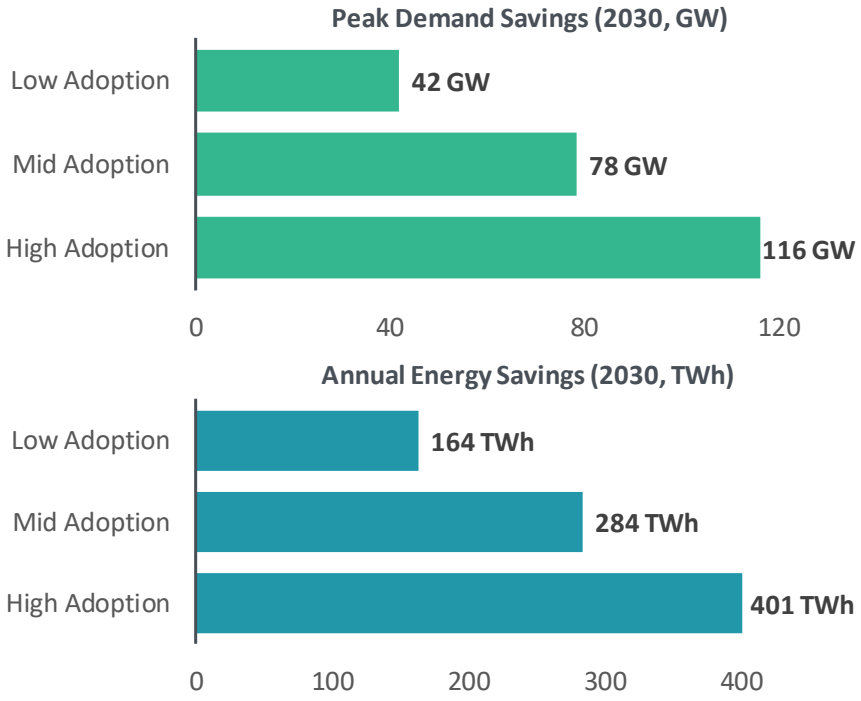
Grid Interactive Efficient Buildings Are Integrated

Grid Interactive Efficient Buildings (GEBs) Communicate with Grid and Optimize Use of Clean Energy

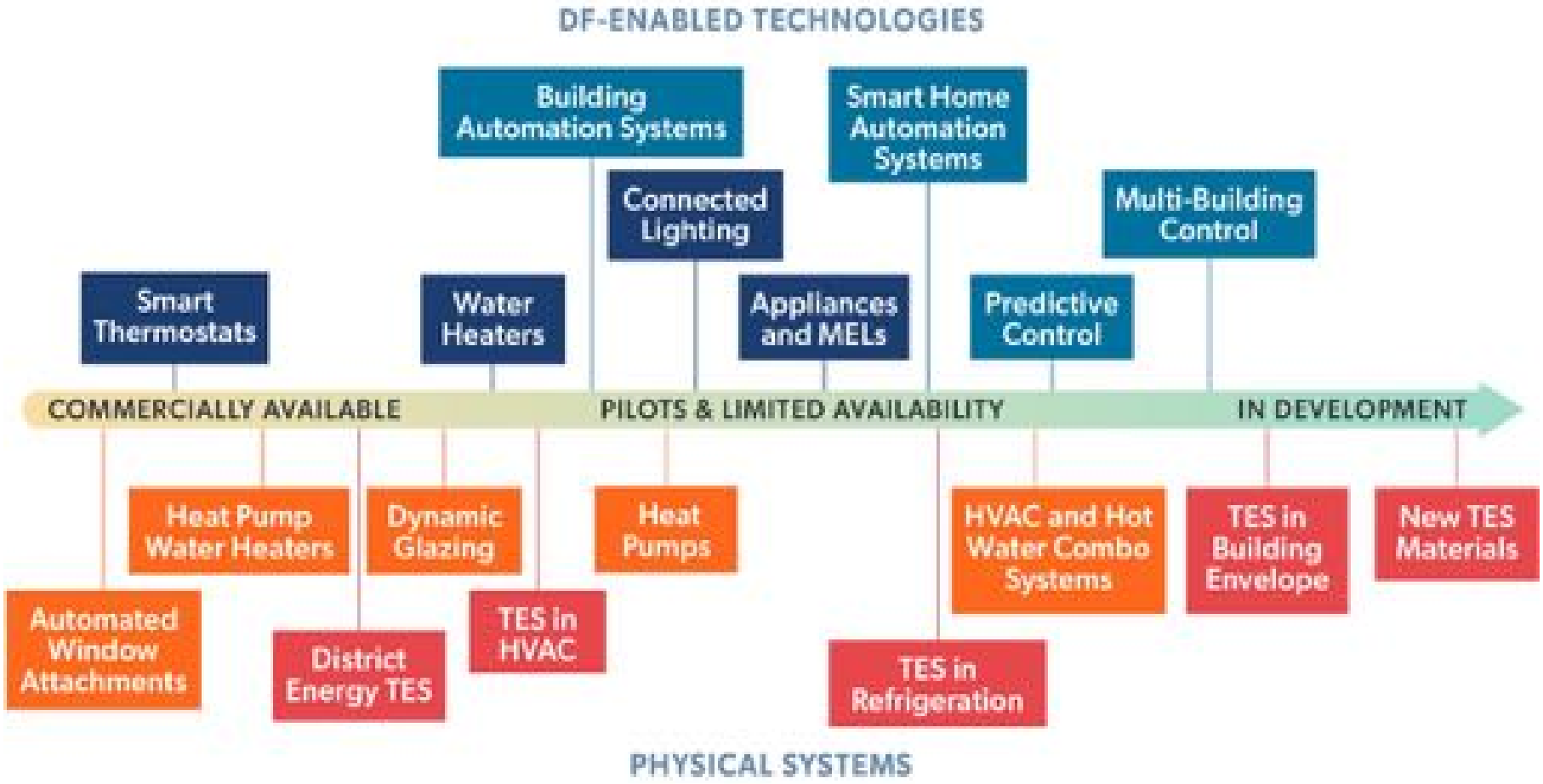


GEBs could save up to $18 billion per year in power system costs by 2030, or roughly $100 to $200 billion between 2020 and 2040





GEB Technology Will Unlock Opportunities to Improve Building Efficiency plus Deep Grid-Interactivity



Need to expand control R&D to integrate with PV, EVs, Elec Storage

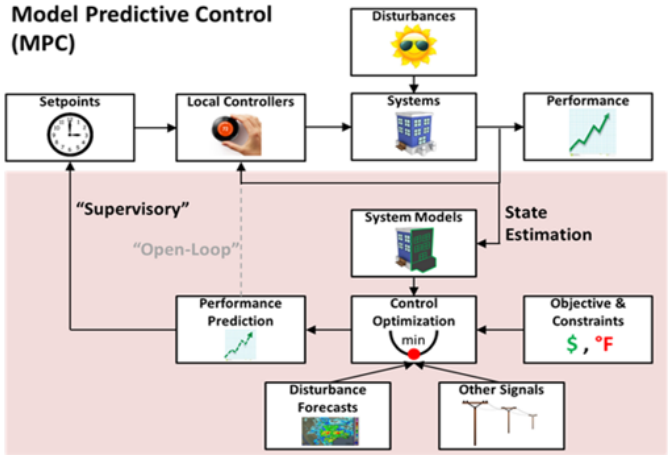
GEB Predictive Control Reduces GHG and Energy Costs

Predictive Control with PV and Thermal Energy Storage

- Identified optimal control for campus chiller plants w/ TES and PV to decarbonize and stabilizing the grid

Societal/Market Impact

- CO2 reduction of ~ **1 mTCO2e/day** while reducing peak demand $.
- Approx **2500** miles in a car at 22 mpg.

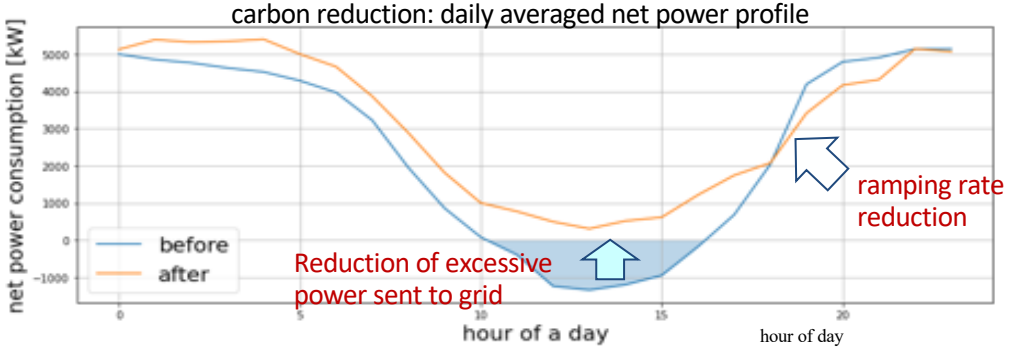


UC-Merced Campus

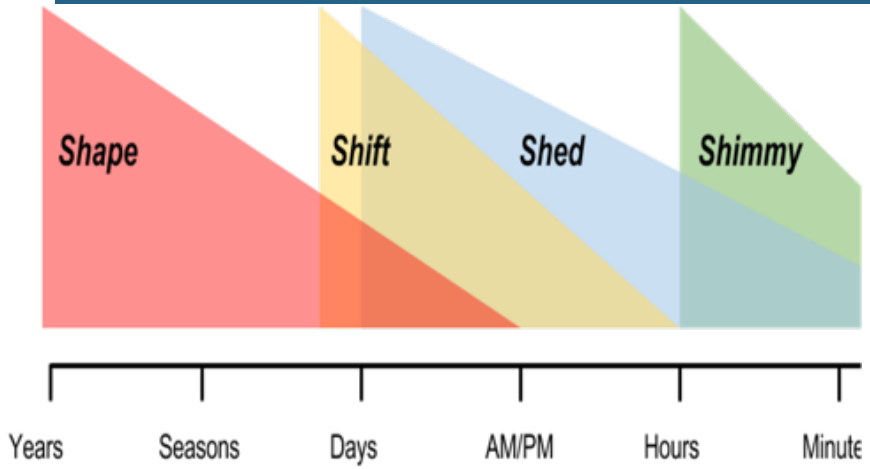
2 M gallon TES

4 MW Solar Farm

Experimental assessment of renewable energy integration and carbon reduction: daily averaged net power profile



3. CPUC Demand Response Potential Studies Explores Size and Value of GEBs



- **Shape**: persistent daily load modifications
- **Shed:** acts like virtual **generation** capacity
- **Shift**: acts like a virtual **storage** resource
- **Shimmy**: acts like a virtual **regulation**/ancillary services resource

- Phases 1, 2 and 3 provided the shed capacity (GW) and shift (GWh) from GEBs. Buildings could provide about 2 GW at $200/kW-yr Levelized cost for 2025.
- Current modeling (Phase 4) will cover new end-uses and update customer data.
- Key questions: **How large** is Shed and Shift resource, **where** are resources and **when** is it available, and at **what cost**?
- **Key takaway:** Shift can play important role in California's renewable grid, but it will need to grow. We can explore ways to bring down costs and drive participation.

Enabling Technology Modeling Framework

Components:

Costs

- Initial
- Operating

Performance

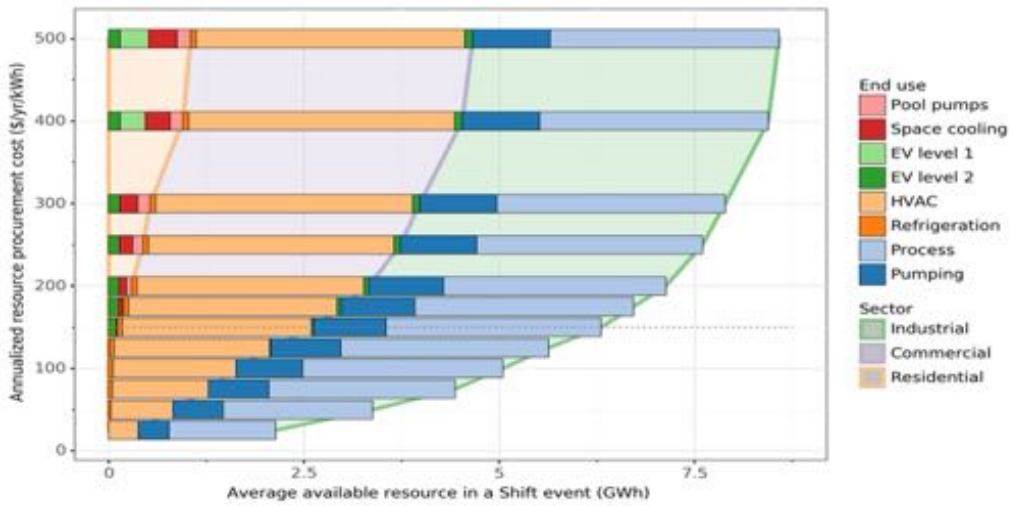
- Speed of response
- Magnitude
- Persistence

Propensity to Adopt

- Based on customer factors

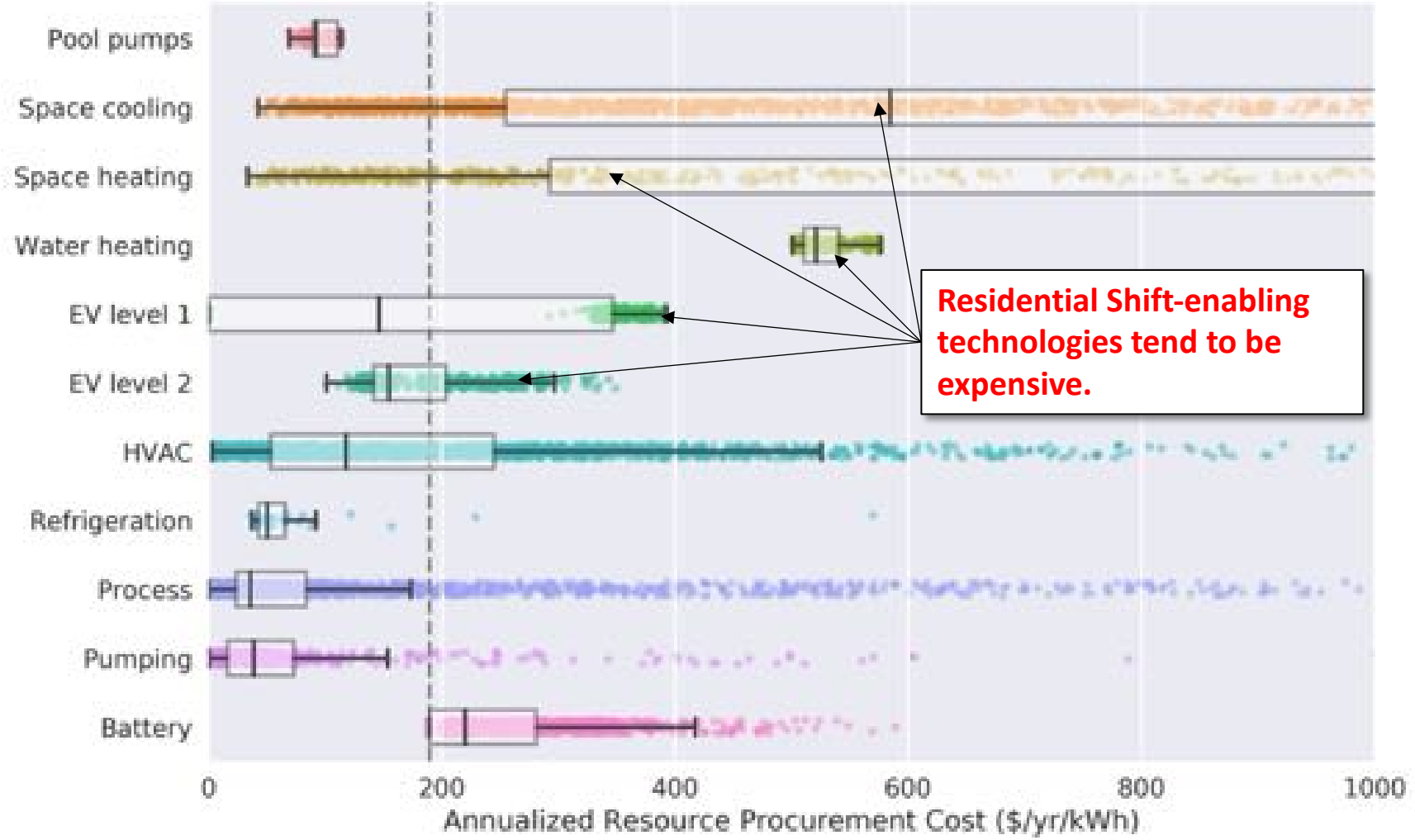
Shift Supply Curve for 2030

Battery threshold (reference price)



- **Shift DR** in California: 4-6 GWh of *virtual storage* cheaper than BTM batteries (~$150/yr/kWh), about 40% from buildings, a significant portion of current grid challenges.
- **Electrification** will introduce a new Shift resource, modeled in new Phase 4.
- Shift resource will be **much larger** if customer participation is higher than observed historically for Shed DR.
- With ~1 percent of load shifted in 2017, ~150 GWh of total curtailment could have been avoided (~ 50 % of curtailment), replacing non-renewable generation with zero-carbon renewable energy.

Cost Barriers to Enabling Shift
Reducing technology costs can unlock new resources



End-Uses Considered in Cluster Load Shapes

Recent updated AMI data analysis expands scope of buildings and end uses

Residential Sector		**Commercial Sector**	
Building Types	End Uses	Building Types	End Uses
• Single-family • Multi-family • Master meter	• Cooling • **Heating** • Ventilation • Indoor Lighting • Outdoor lighting • Cooking • Dishwasher • Clothes Washer • Clothes Dryer • Refrigerator • Freezer • Pool pump • Spa heater • Spa pump • Television • Office equipment • PCs • **Water heating** • EV level 1 • EV level 2 • Rooftop PV	• Office • Retail-food • Retail-other • Dining • Lodging • Medical • Education • Assembly • Datacenter • Warehouse • Refrigerated warehouse	• Cooling • Heating • Ventilation • Indoor lighting • Outdoor lighting • Office equipment • Refrigeration • Water heating • Datacenter IT • Misc. • EV charging • Rooftop PV

Entries in **red** under development from AMI data in Phase 4

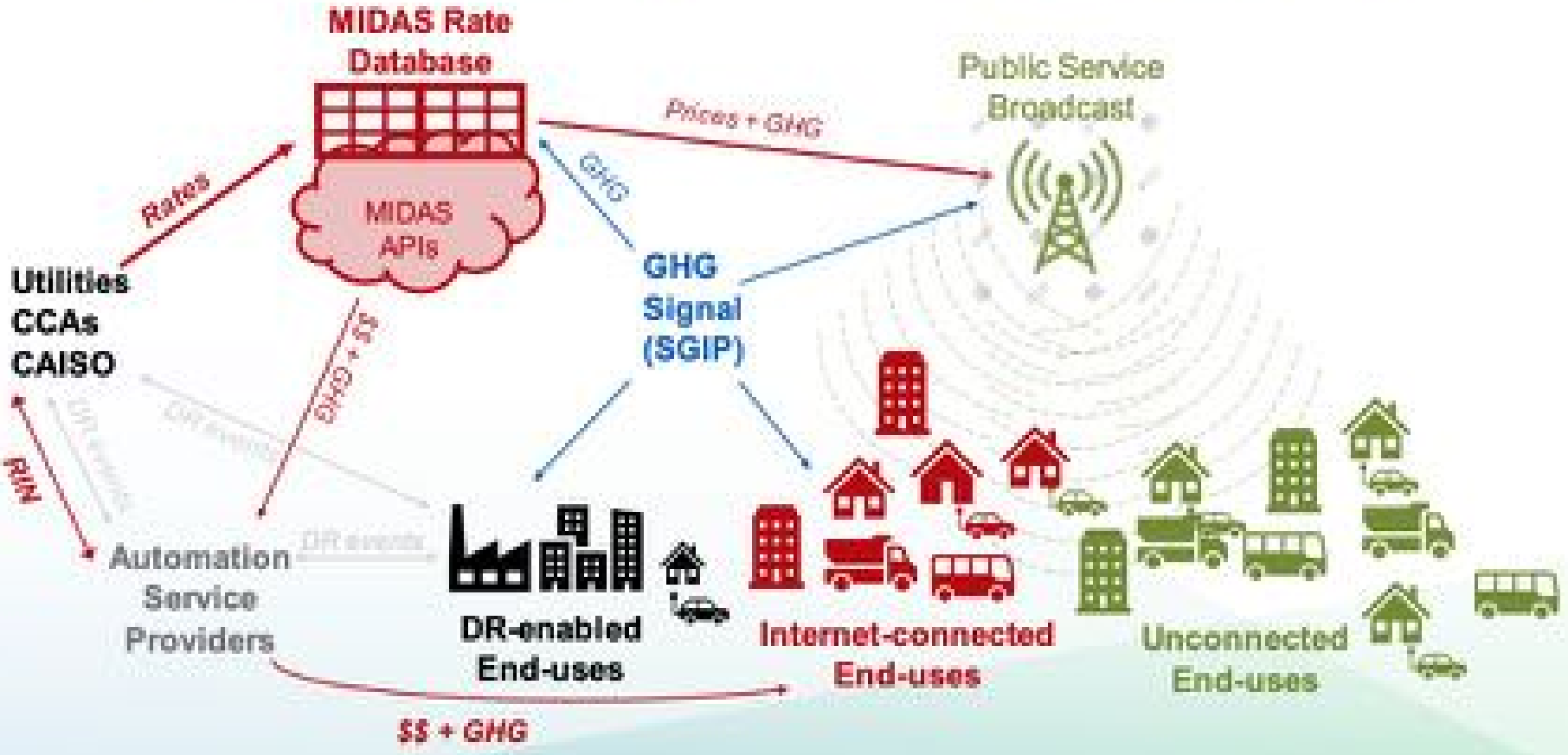
4. The California Load Flexibility Research and Deployment Hub seeks to

Advance the capability of buildings to provide a flexible electricity load for the State of California.

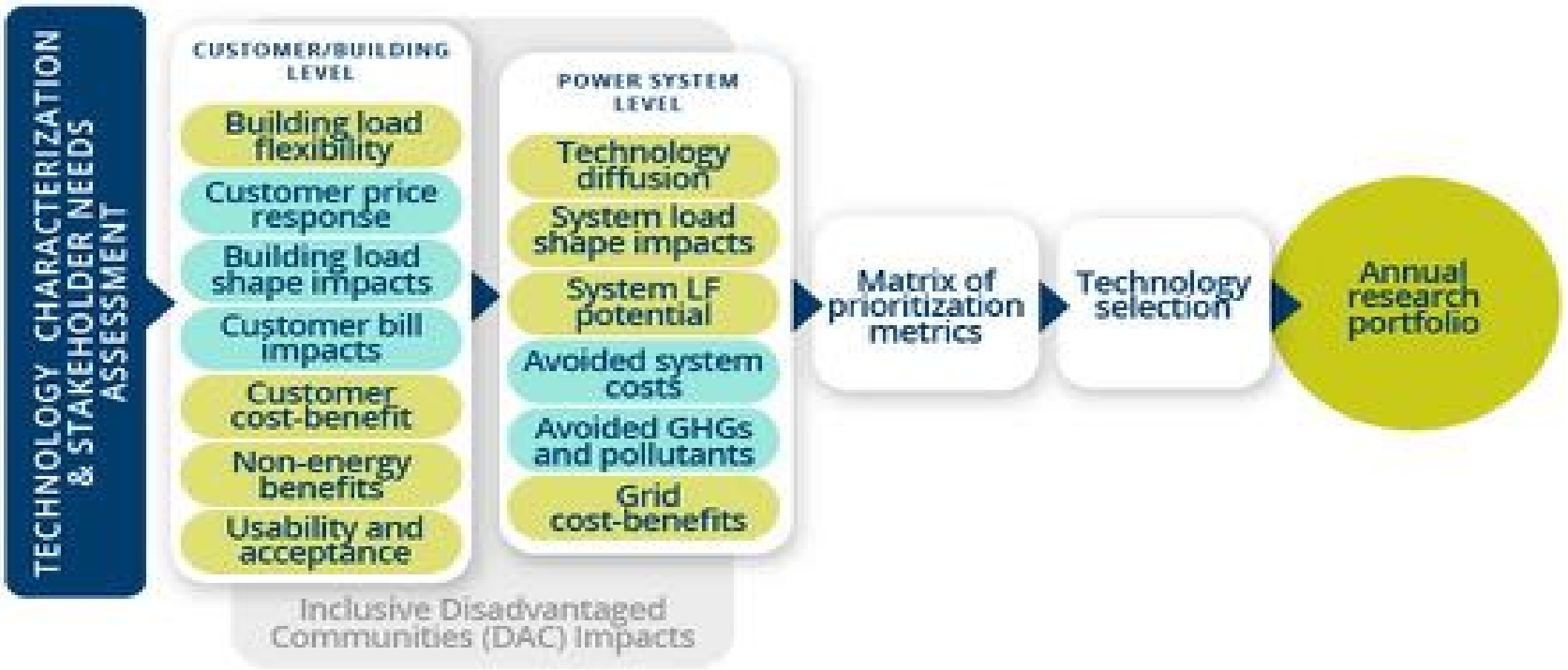
- Identify, evaluate, develop, and demonstrate pre-commercial, load-flexible pre-commercial technologies
- Standardize the signals used to communicate dynamic price and GHG information to these technologies
- Emphasis is Load Shaping DR but CalFlexHub will also evaluate supply-side DR

Long-term Vision: Public Broadcast

Time-varying rates and greenhouse gas (GHG) signals



Annual Technology Assessment Process



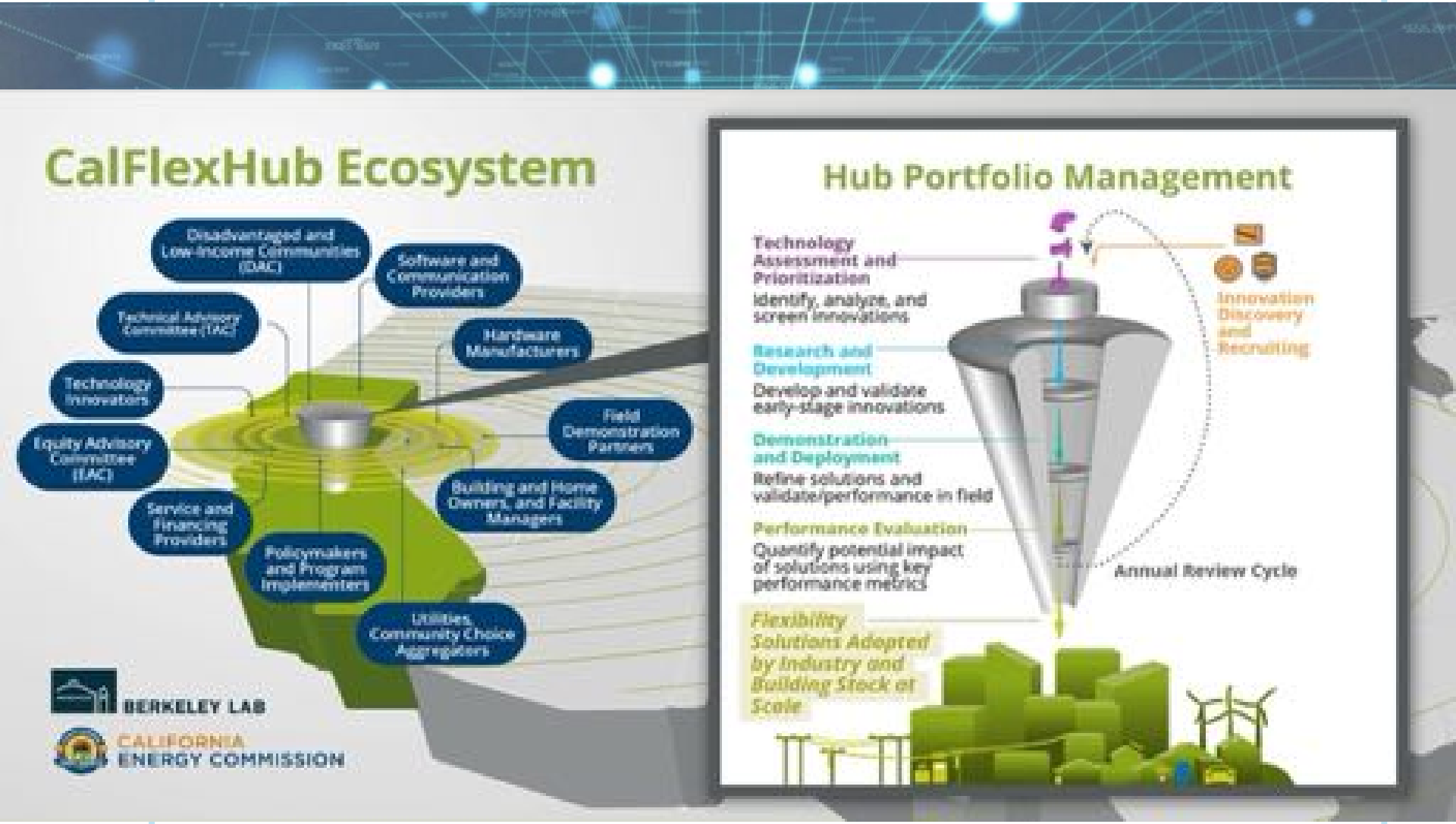
Portfolio management framework for valuation of impacts of CalFlexHub technology portfolios and development of annual research portfolio. Berkeley Lab models (green); E3 models (turquoise).

Six Applied R&D Projects – Lab and Initial Demo Sites

		Funded Partners	Other Partners	Location/Sites
A1	**Residential Smart Fan with Integrated Thermostat**	UCB	Big Ass Fans	UCB, Stockton Senior Center
A2	**Dynamic Heat Pump for Residential Space Heat and DHW**	UCD	Ecobee, Rheem, Carrier	UCD, Future Multi-Family Site
A3	**Dynamic Space Heat for Small Commercial HVAC**	LBNL	Melrok	LBNL FlexLab, EPIC HP-Flex Sites
A4	**Integrated Heat Pump and Cold Storage for Small Commercial HVAC**	LBNL	Sunamp, Aermec, UCD Facilities	UCD
A5	**Model Predictive Control for Dynamic Large Commercial and District Energy Systems**	LBNL, UCSD	UC Merced Facilities	LBNL, UCSD, UC Merced
A6	**Home Energy Management System to Maximize Electrical Panels with Electric Storage**	LBNL	Orison, Heila, Span.io	LBNL

Six Technology Demonstration and Deployment Projects – Field Sites

		Funded Partners	Other Partners	Location/Sites
T7	**Integrated Small Commercial Energy Management with DERs**	UCD, Extensible Energy	Gridpoint	UCD
T8	**Integrated Heat Pump with Storage for DHW and Space Conditioning**	UCD	Villara	Nor Cal Homes
T9	**Residential HVAC and Hot Water Using Integrated Storage**	LBNL, Harvest Thermal		East Bay Homes
T10	**Household Flexible EV Charging**	UCB	BMW	California Homes
T11	**Bi-Directional EV Charging**	UCD	Honda	UCD and UCSD
T12	**Control and Coordination of Distributed Flexible Loads**	Olivine, SkyCentrics	Ecobee, Pentair, Sonoma Clean Power, Belmont Redwood Shores Schools, Richmond MSH Properties, City of Pittsburg Unified Schools, UCB Richmond Field Station	Belmont, Richmond, Pittsburg, Sonoma, LA County, and others


CalFlexHub Ecosystem
Disadvantaged and Low-Income Communities (DAC)
Software and Communication Providers
Technical Advisory Committee (TAC)
Hardware Manufacturers
Technology Innovators
Field Demonstration Partners
Equity Advisory Committee (EAC)
Building and Home Owners, and Facility Managers
Service and Financing Providers
Policymakers and Program Implementers
Utilities, Community Choice Aggregators
BERKELEY LAB
CALIFORNIA ENERGY COMMISSION
Hub Portfolio Management
Technology Assessment and Prioritization
Identify, analyze, and screen innovations
Research and Development
Develop and validate early-stage innovations
Demonstration and Deployment
Refine solutions and validate/performance in field
Performance Evaluation
Quantify potential impact of solutions using key performance metrics
Flexibility Solutions Adopted by Industry and Building Stock at Scale
Innovation Discovery and Recruiting
Annual Review Cycle

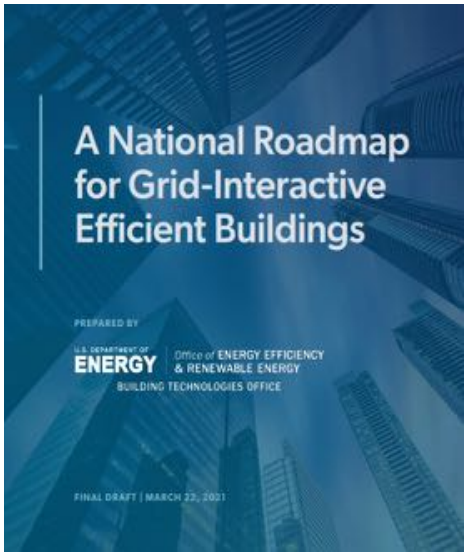
Equity

CalFlexHub seeks to benefit all Californians, including those from disadvantaged communities.

Target technologies will be practical, affordable, and reliable.

Signals will be broadcast over the internet and via FM radio waves—accessible to virtually every household and business in California.

5. Summary and Future Directions



- **GEBs are critical for decarbonization**
- **Key technologies**: heat pumps, envelope, controls, communications, integration with EVs, PV, storage
- **Customer Engagement**: We need more of it!
- **The California Load Flexibility Research and Deployment Hu**
  demand