California ENERGY COMMISSION

BERKELEY LAB

MOMENTUM

CALFLEXHUB 2026 Symposium

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Research Spotlight: Valuing the CalFlex Hub Pipeline

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Valuation of Load Flexibility Technologies

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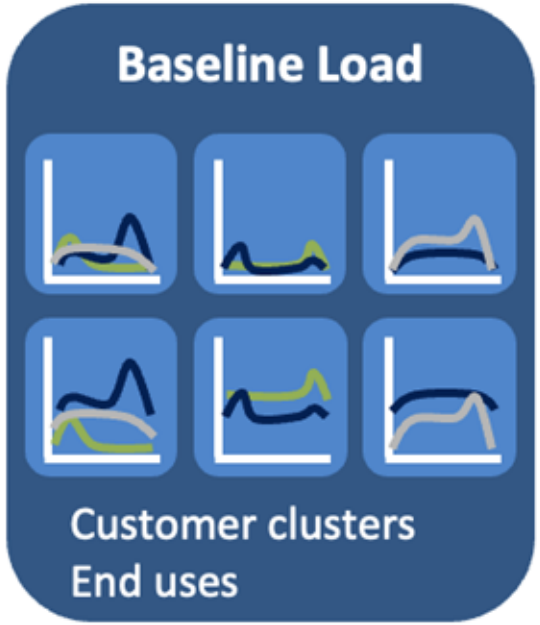
BERKELEY LAB

The **goal** is to assess the costs and benefits of load flexibility technologies to customers and the grid

The **approach** is modeling widespread future adoption of technologies, present-day costs and performance, and hypothetical price signals



Analysis Overview

- Deep-dive on modeling for **six key technologies** leveraging testing and simulation results from demonstration project teams
- **Updated assumptions** for technology performance and costs, including uncertainty analysis
- Uncertainty analysis considering range of **performance scenarios**
- **New price profiles** reflective of forecasted 2030 electricity costs and system net load (from recent CPUC work)

Technologies Assessed

Technology	Relevant CFH Project(s)	End use(s)	Building type
Residential Integrated Heat Pump	A2	Heating, Cooling, Water Heating	Single & multi-family residential
Commercial Building MPC	A5B, T12A.3, A3	Heating, Cooling	Commercial buildings (Various)
Residential EV Charging	T10, T12A.4	EV Level 1, EV Level 2	Single & multi-family residential
Residential Connected Thermostat	T12A.1, T12A.2	Heating, Cooling	Single & multi-family residential
Residential Pool Pump	T12B.1	Pool pump	Single & multi-family residential
Residential Unitary HPWH	T13	Water heating	Single & multi-family residential

Customer Base

- **Customer load clusters** (by sector, size, type, ...) for California
- Projected baseline **load shapes** from CPUC DR potential study

Each Cluster

Baseline

Load shapes for affected end use(s)

Total cluster load shape

BAU end use equipment saturation (e.g. assuming electrification)

+

Flex Technology

End-use(s)

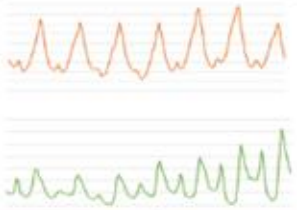
Performance: Shift, RTE

Cost Differential

Lifetime

Price signal

(Avoided Cost Calculator-based OR Dynamic Retail Price)



Cluster-level Load Shape Impacts

Flexible load dispatch based on price optimization using E3's RESTORE model

Electricity Bill Savings

Grid Impacts

Grid Cost & Benefits

Modeled by E3 using the Avoided Cost Calculator framework

Event-based shed and shift DR potential

Estimated using DR potential study frameworks

Customer Impacts

Customer Net Cost/Benefit

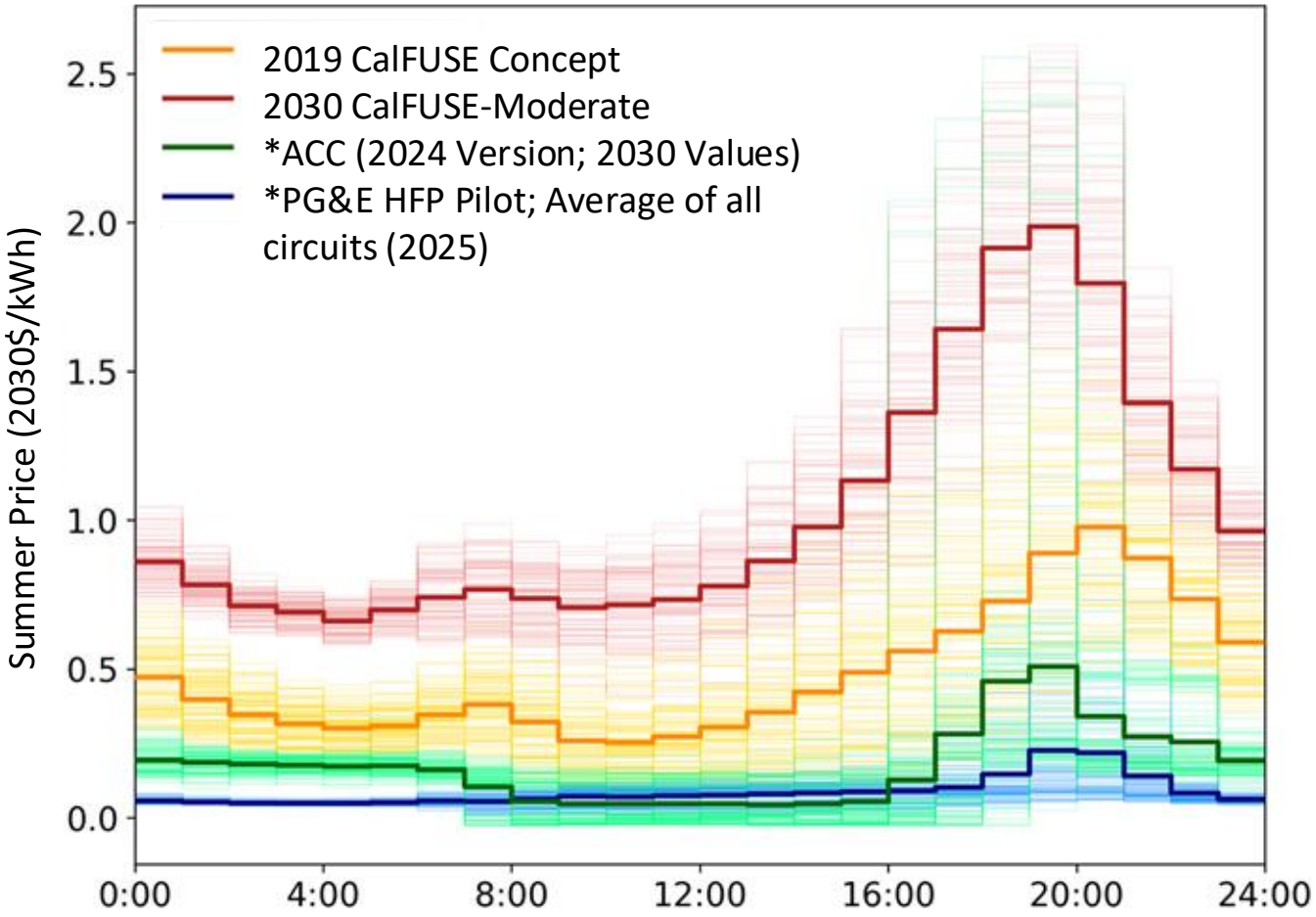
Customer sample (lifetime distribution, costs and bill savings range)

Simple payback period

Costs and benefits per customer segment

Price Profiles - Scenarios and Uncertainties

- LBL developed dynamic price profiles based on CPUC CalFUSE framework; represents a fully volumetric rate
  - Earlier project cycles used 2019 prices, with all costs allocated dynamically
  - Now have prices forecasted to 2030, with 50% of costs allocated dynamically and 50% held constant in each hour
- CPU Avoided Cost Calculator hourly costs are also used as an alternate proxy price
- Prices now available from PG&E dynamic pricing pilot; modifier to baseline TOU rate

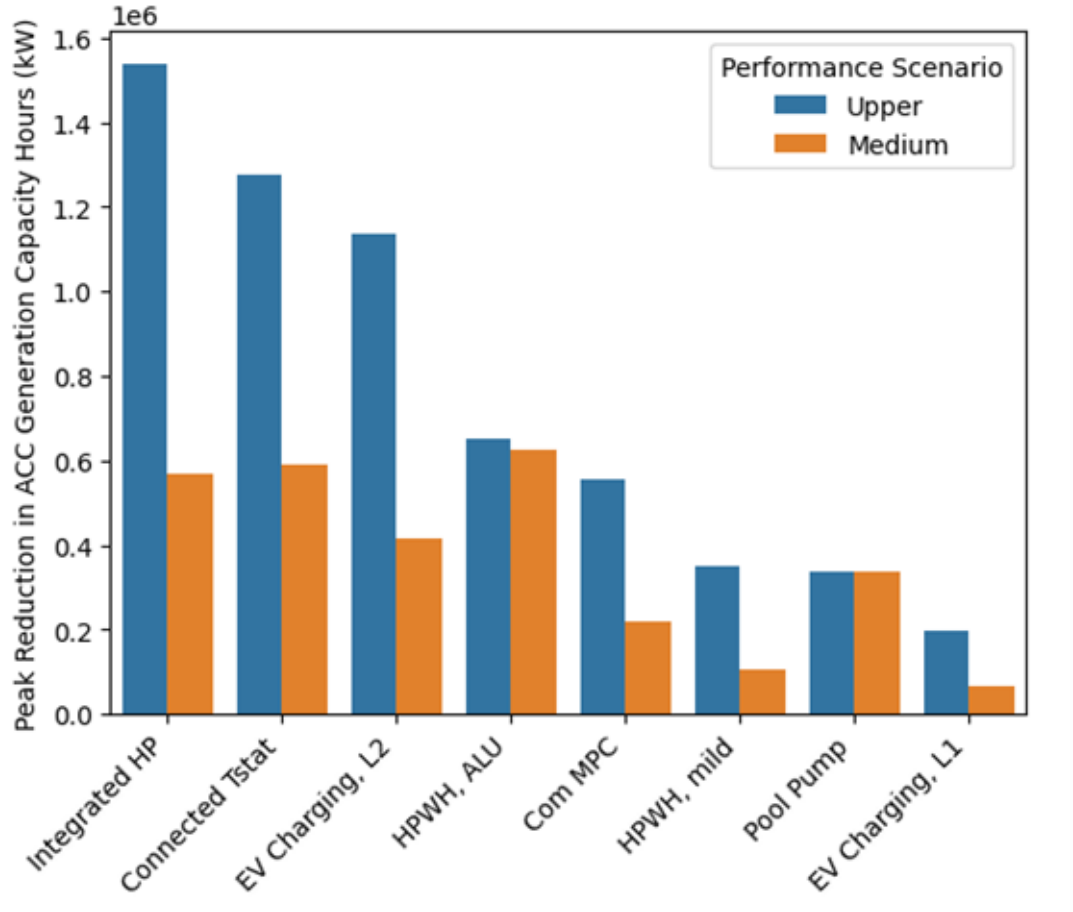


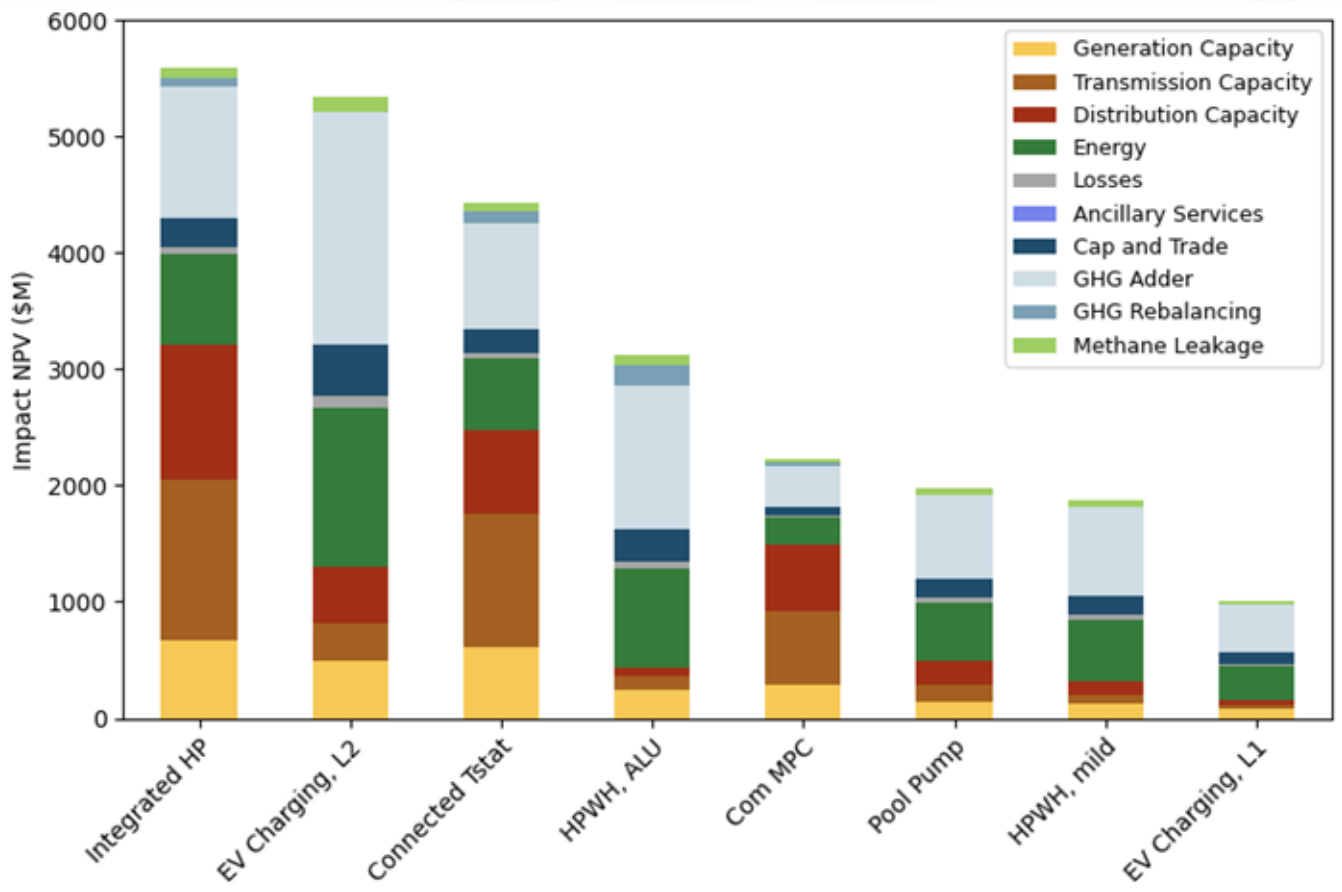
**ACC and HFP use subscriptions where a set baseline load is charged at a TOU rate, then any incremental electricity consumption is charged at the ACC or HFP rate, respectively.*

Performance Assumptions

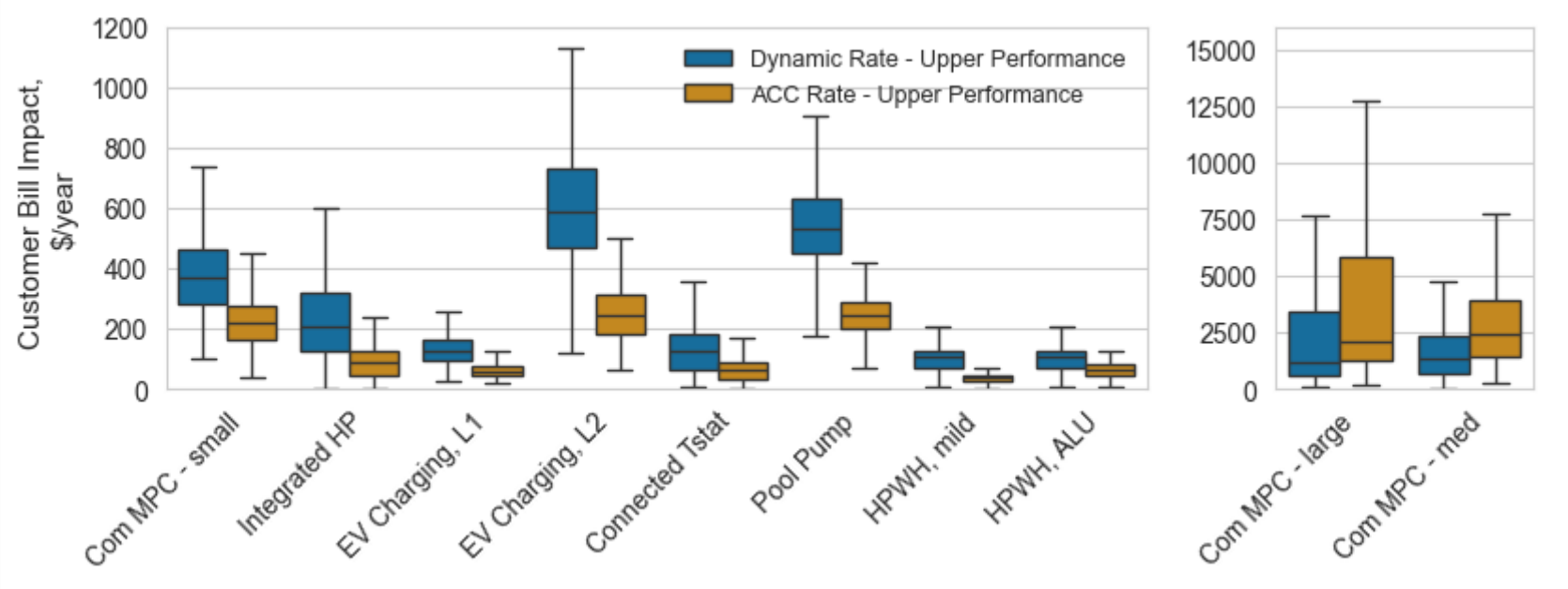
Technology	Upper Performance		Medium Performance		Round-Trip Efficiency	Sources and Notes
	Shift Window (hours)	Shed Depth (%)	Shift Window (hours)	Shed Depth (%)		
Integrated HP, Space conditioning	4	90	2	90	0.90	Informed by CalFlexHub preliminary field-testing results.
Integrated HP, Water Heating	7	52	4	41	0.98	Based on field demonstration results for unitary HPWHs (Gabriel et al. 2024).
Com. MPC, Large Bldgs	8	65	4	65	0.90	Based on CFH field demonstration results (Zanetti et al. 2025)
Com. MPC, Medium Bldgs	6	65	3	65	0.90	Assumes 75 % of shift window compared to large buildings. 3-hour window was demonstrated in (Morovat et al. 2025).
Com. MPC, Small Buildings	4	65	2	65	0.90	Assumes 50 % of shift window compared to large buildings. Values are similar to residential thermostats, but MPC can modulate load over longer periods in the upper performance case.
EV Charging, L1	6	80	4	70	1.00	(Biesecker, Pivirotto, and Havenar-Daughton 2024; ev.energy corp 2021; Singh, Vaidya, and Mouftah 2022; Almaghrebi et al. 2024).
EV Charging, L2	6	100	4	90	1.00	
Connected Thermostat	3	90	2	60	0.85	Informed by CalFlexHub preliminary field-testing results.
Pool Pump	12	90	10	90	1.00	No change in efficiency as the pump can run at the same speed, just at a different time.
HPWH, mild	7	52	4	41	0.98	Field demonstration results (Gabriel et al. 2024).
HPWH, ALU	8	100	6	98	0.73	Additional modeling using methodology in (Grant et al. 2025).

Grid Impacts of Ubiquitous Price Response





Customer Bill Impacts of Price Response

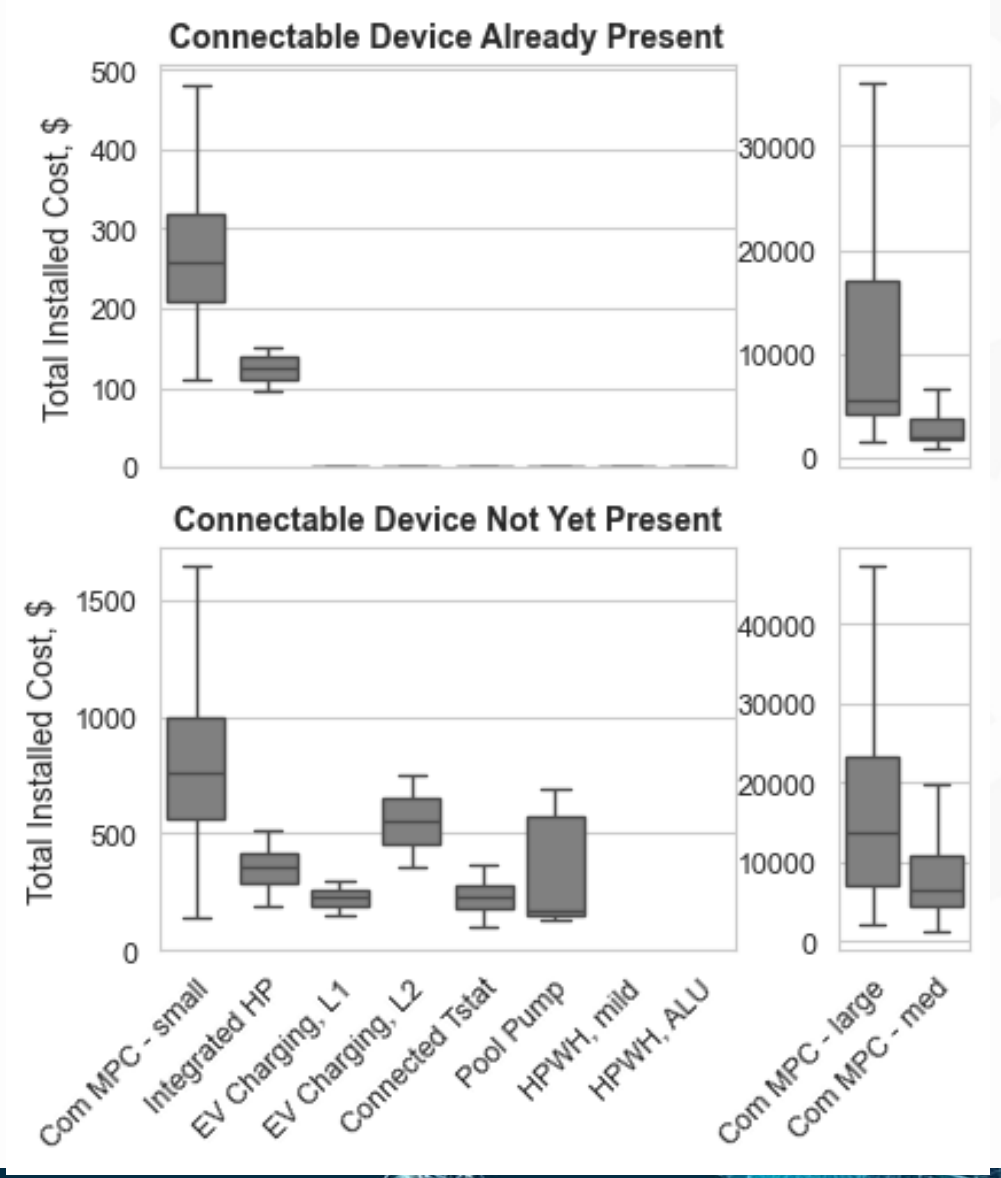


- Wide range of savings across individual customers
- Year-round end uses (pool pumps, water heating, EV) save more when responding to the Dynamic Rate; large cooling loads perform better on the ACC rate
- Medium performance scenario (not shown) makes significant difference across all technologies, except ALU WH which has relatively consistent savings across scenarios

Cost Assumptions

- Customer base is segmented based on assumed pre-existing adoption of connectable devices (e.g. thermostats, EV chargers)
  - Water heating price response customer base limited to CTA-2045-ready equipment
- Cost sensitivity scenario excludes installation and maintenance/subscription costs, reflecting:
  - Potential programs covering installation costs
  - Uncertainty in business models; how price responsive functionality will be paid for
- Some costs have large ranges due either to uncertainty or different scaling across customer sizes

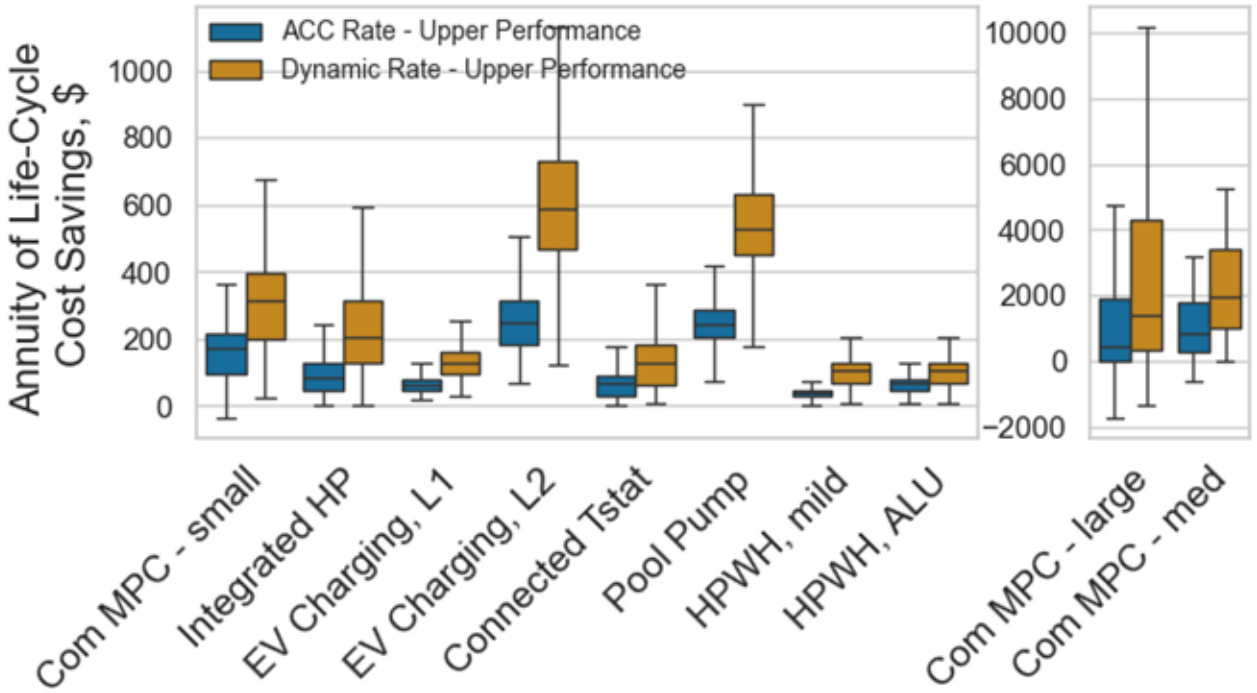
Up-Front Load Flex Technology Costs



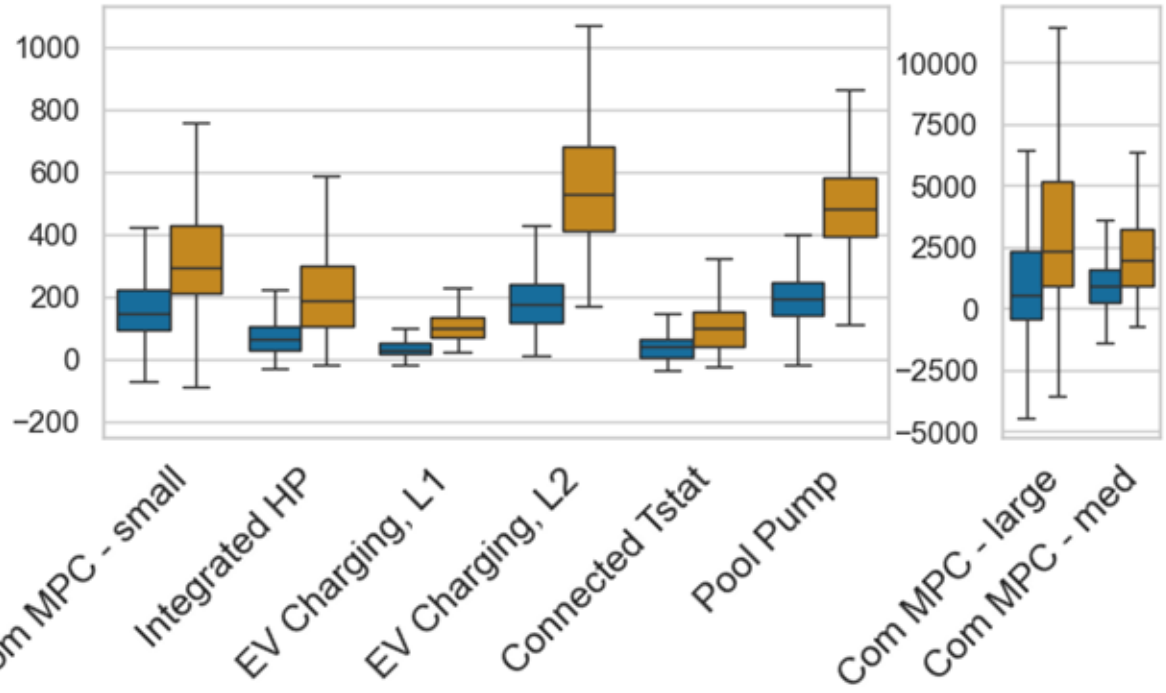
Customer Net Annual Savings

Excluding Installation and Maintenance Costs

Connectable Device Already Present

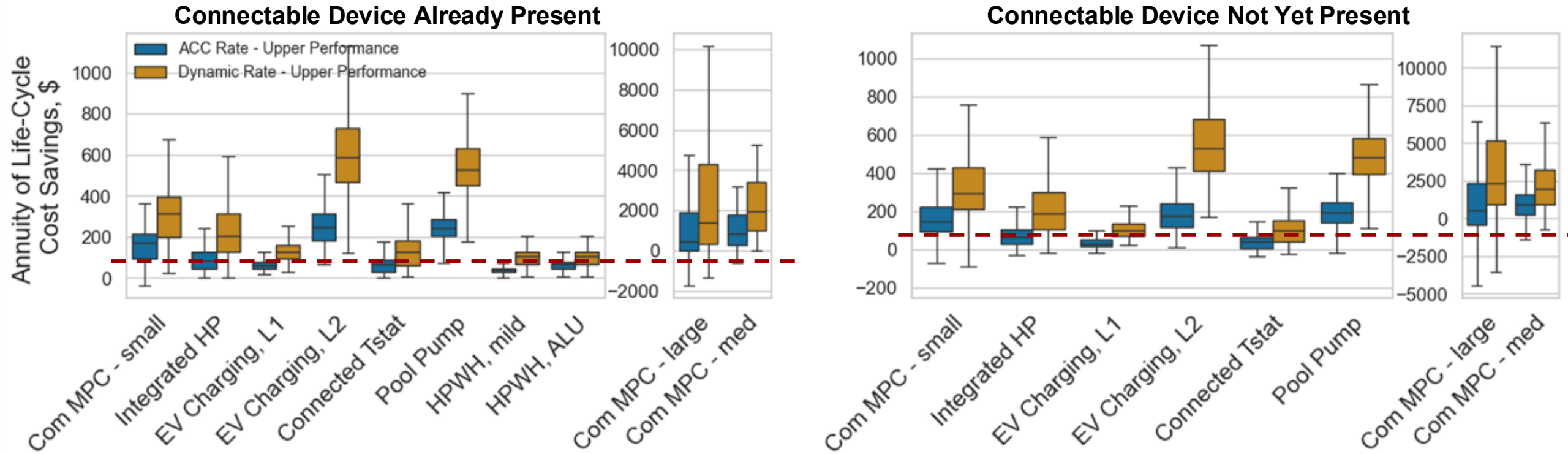


Connectable Device Not Yet Present



Customer Net Annual Savings

Excluding Installation and Maintenance Costs

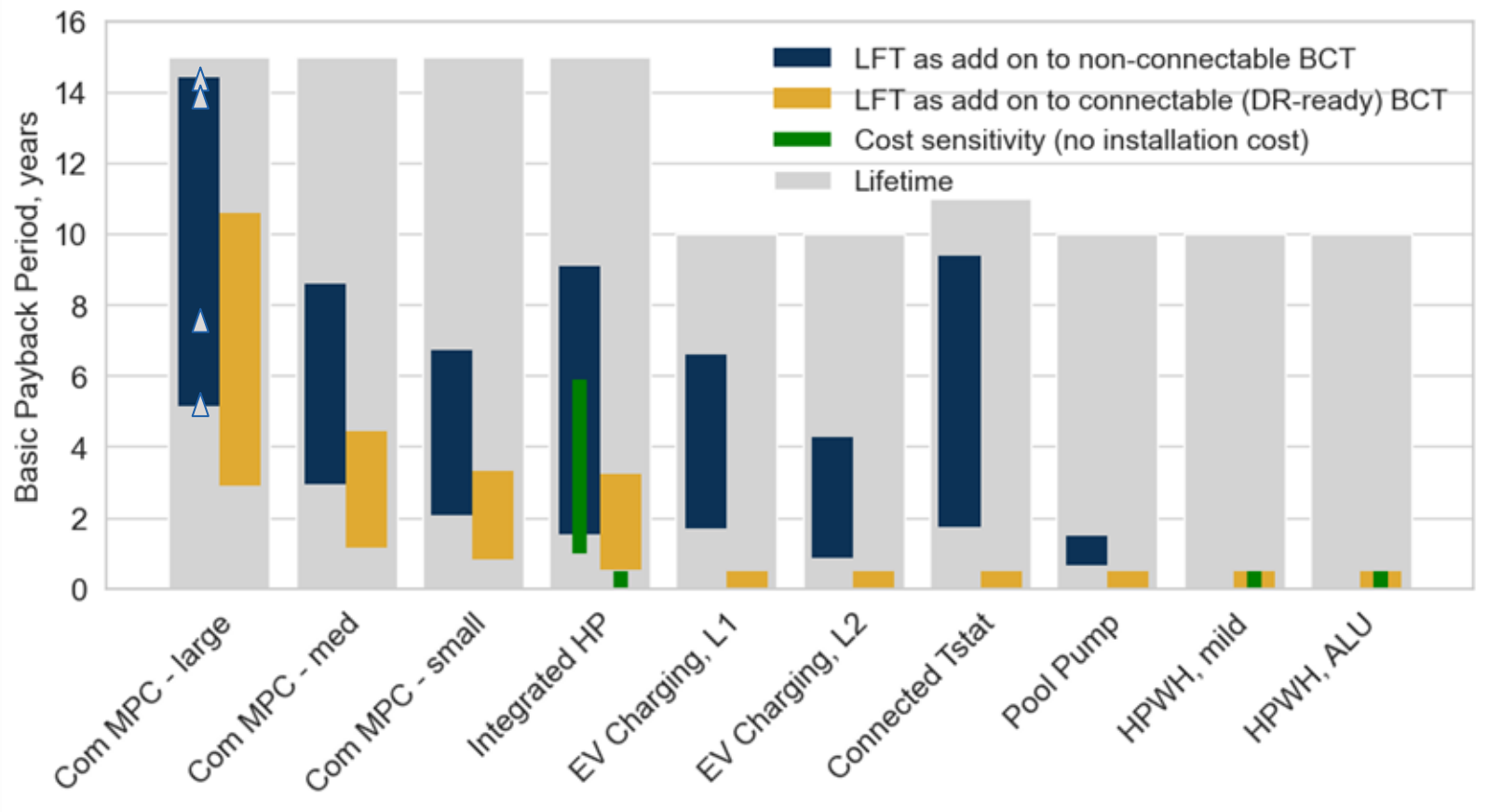


Additional costs for price response feature subscription ~$10/month erodes savings for several technologies.

Average Payback Period

Excluding Ongoing Service Fees for Price Response

- In the DR-ready case, median PBP < 5 years for all techs across scenarios, except large commercial MPC
- Upgrading non-connectable equipment makes sense financially in some scenarios
- MPC: PBP increases with building size; upper performance PBP < 7 years
  - Costs are assumed to scale with size of building
- Impact of ongoing services fees on PBP to be explored further



Conclusions

- Price response can provide significant DR and grid value
- Many customers have devices that are connectable but lack price-responsive features; cost of these features to customers (if any) will drive net customer value
- EV charging and pool pumps provide significant value to customers regardless of (reasonable) feature costs
- Commercial cooling MPC can provide $1000s in annual bill savings, but payback period will be sensitive to actual commissioning costs, dynamic price profile, and technology performance

Future activities should aim to:

- Create more certainty in future price profiles; especially if needed to justify investments in hardware or software commissioning
- Continue to evaluate performance of price responsive technologies across buildings and conditions
- Track and synthesize costs of price-responsive technologies, including ongoing costs (or lack of) for price-responsive features

NEW: California Price Response Potential Study

- Study explores three dynamic price designs for two 2030 price forecast scenarios
- New models developed for representing price response of six end uses across three sectors
- Results explore technical and economic potential of price response
- Available at https://emp.lbl.gov/publications/california-price-response-potential
- Webinar forthcoming; email sjsmith@lbl.gov for info