CalNEXT Knowledge Sharing Webinar

Residential Energy Technologies

April 14, 2026

ENERGIZING CALIFORNIA'S FUTURE

Energy Solutions, AESC, TRC, UC Davis, VEIC

Program paid for by ratepayers

Agenda

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Phase Change Material Applications in Residential Water Heating	VEIC	9 min
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Performance Evaluation of Advanced HEMS	UC Davis	9 min
Field Demonstration of Electric Clothes Dryer Controller	Franklin Energy	9 min
Laboratory Evaluation of Residential Smart Panels	UC Davis	9 min
Electrification Enablement via Load Balancing Solutions Focus Pilot	TRC	9 min
Wrap-up	Energy Solutions	2 min

Presenters

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Phase Change Material Applications in Multifamily Water Heating

Project Outcomes and Tech Transfer

Emma Casavant, VEIC
Rose Wall, VEIC

Agenda

1 Project Summary

2 Baseline and Proposed Updates

3 Stakeholders

4 Savings

5 Next Steps

California Multifamily Water Heating Electrification Challenges

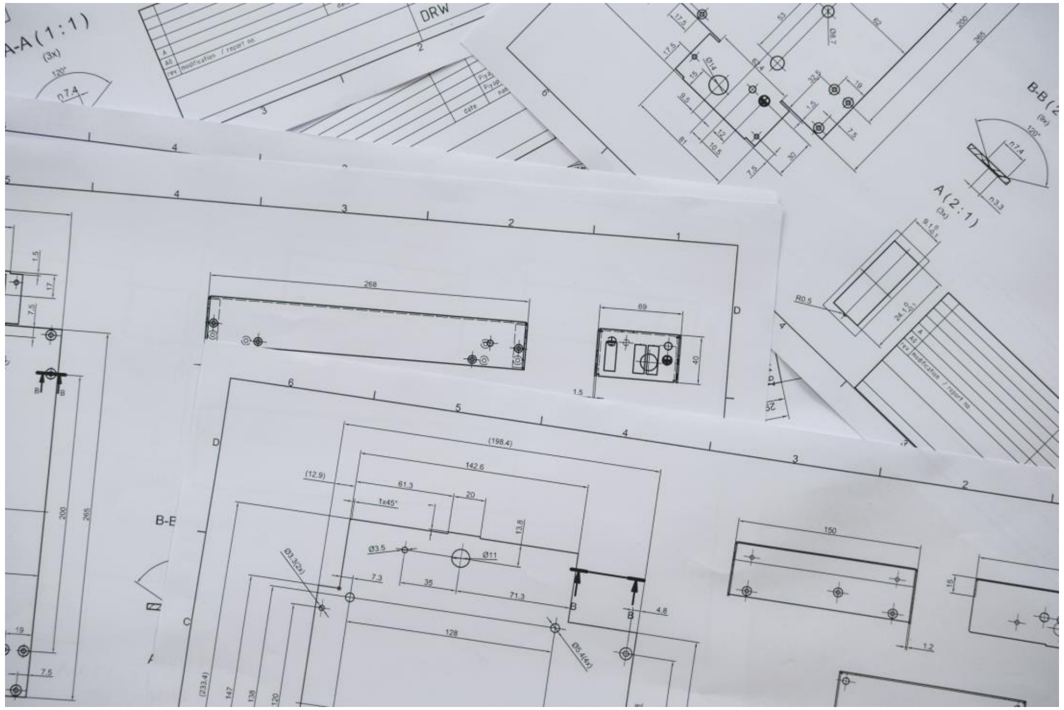
Key Points

- California's multifamily sector seeks solutions to decarbonize domestic hot water (DHW)
- Central heat pump water heaters (CHPWHs) are gaining traction, but face persistent barriers in retrofits: space constraints, high first costs, and inefficient recirculation systems
- Phase change material can complement CHPWHs by offering compact, high-density thermal storage and the potential to reduce circulation losses, shift electric loads, and downsize central storage—all critical needs in multifamily buildings

Project Overview

Objectives

- Evaluate the opportunity and performance potential of Phase Change Material Thermal Energy Storage Systems (PCM TESS) in multifamily DHW applications
- Develop optimized engineering concepts integrating PCM into central DHW systems
- Provide insights for utilities, manufacturers, and policymakers to inform future program design and market transformation



Methods

- Conducted literature review, stakeholder interviews, engineering design, and comparative energy/cost modeling to assess PCM TESS feasibility and performance

Distributed PCM TESS Design Scenarios in California Multifamily

Questions Answered by the Project

- What is PCM and how does it perform?
- Can distributed PCM **reduce recirculation heat losses** in central DHW systems?
- Can PCM support **load shifting** for CHPWHs?
- What types of buildings benefit most?
- What are the **installation barriers**, **program compatibility issues**, and **adoption challenges**?
- How can these systems fit into **California's decarbonization programs**?

Baseline: Central Water Heating Plant with Boiler or CHPWH

- **The project team developed four scenarios:** two baseline scenarios (Boiler and CHPWH) and two distributed PCM scenarios (Boiler and PCM Storage or CHPWH and PCM Storage)

Stakeholders

PCM Manufacturers

- Interviewed

PCM Researchers and Design Engineers

- Interviewed
- Received draft report feedback

Installers (including TECH Clean California Contractors), Retrofit Specialists, and Distributors

- Interviewed

Program Implementers and Advocacy Organizations

- Interviewed

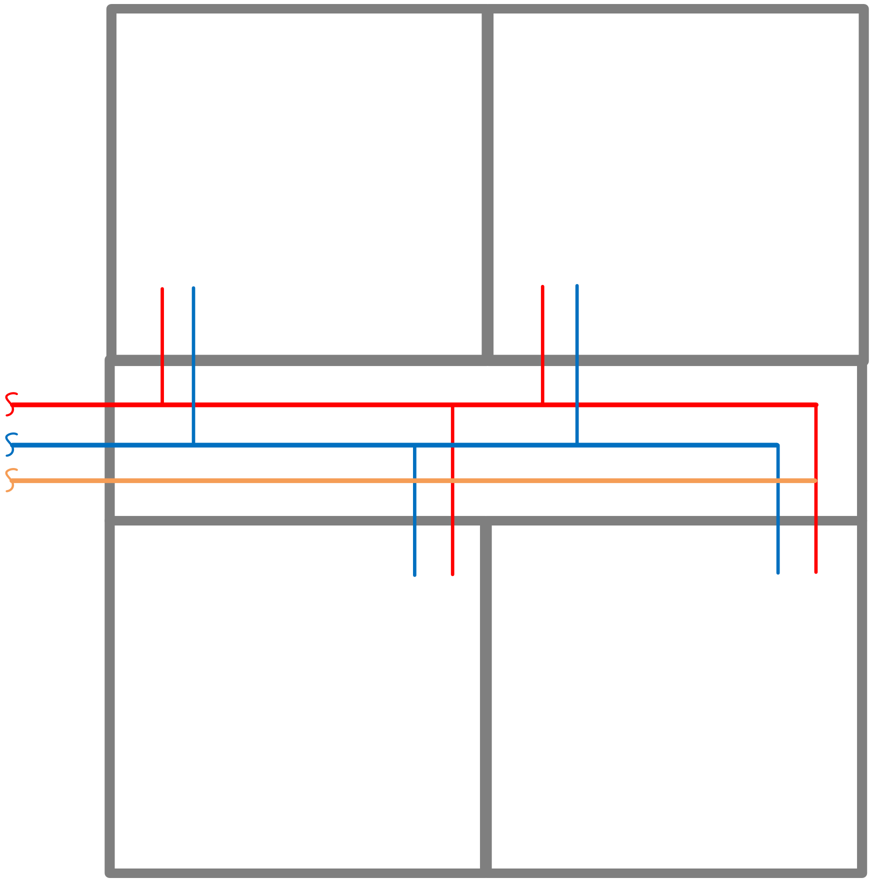
IOU Energy Efficiency PAs

- Informed

Recirculation Loop

→

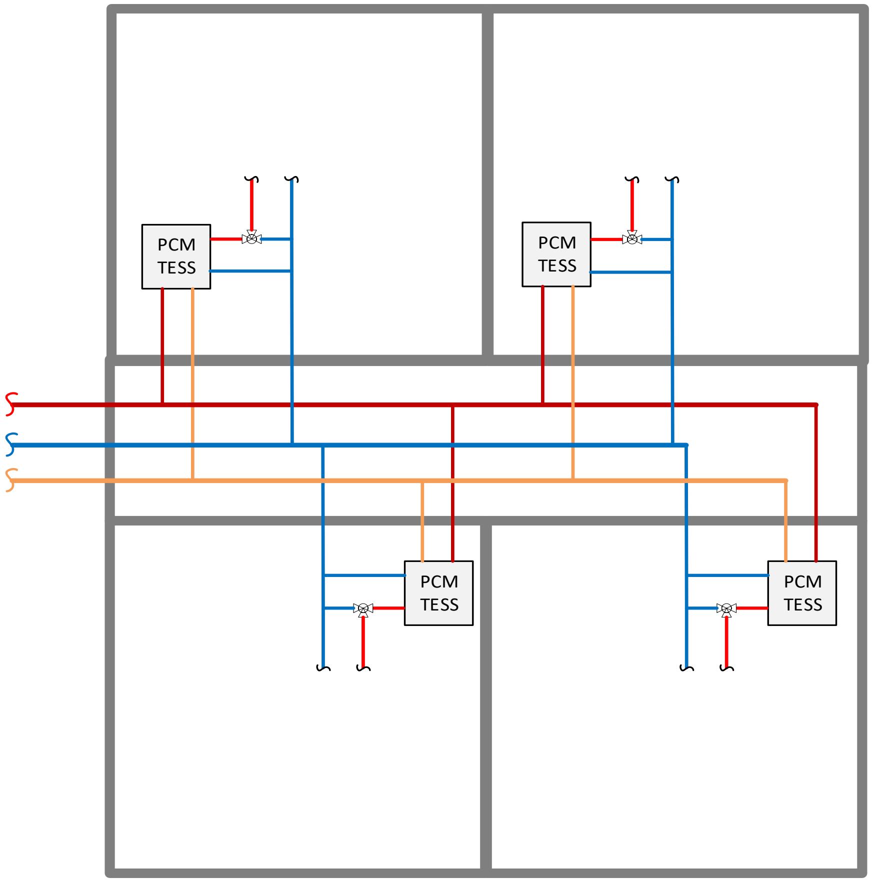
Recharge Loop



Domestic Cold Water

Domestic Hot Water

Recirculation



Domestic Cold Water

Domestic Hot Water

Charging Loop Supply

Charging Loop Return

Summary of Savings – DHW Load

	Baseline Scenarios	PCM Storage Scenarios	Savings
Recirculation Operation (hours)	24	9.2	62%
Annual Recirculation losses (MMBTU)	84	62	26%
Total DHW Load (BTU/day)	753,377	695,629	8%
Recirculation load as percent of total DHW load (%)	30%	24%	N/A

** Assuming a medium rate of existing recirculation heat loss at 100 with apartment or 9,554 BTU/hr for a 28-unit example building

Summary of Savings – Energy Consumption

	Boiler Baseline	Boiler + PCM Storage	Savings
Annual energy consumption (MMBTU)	323.5	298.7	24.8

= 7.6% Savings

Annual Energy Consumption and System COP	CHPWH Baseline		CHPWH + Distributed PCM Storage	
	San Francisco	Lake Tahoe	San Francisco	Lake Tahoe
System COP	2.57	2.54	2.16 ↓	1.93 ↓
Peak Energy Use (kWh)	6,178	8,027	0	0
Partial Peak Energy Use (kWh)	3,149	3,840	0	0
Off Peak Energy Use (kWh)	21,297	23,796	34,467	38,750
Annual Energy Use (kWh)	30,623	35,662	34,467 ↑	38,750 ↑

Shifted Off-Peak

Summary of Savings – Costs, Total System Benefit, and Greenhouse Gases

Annual Electric Costs	San Francisco	Lake Tahoe
Fixed Rate Savings	-$1,064.59	-$813.59
TOU Rate Savings	$160.55	$380.83

= 2.1-4.4% Savings

Evaluation Metric	San Francisco	Lake Tahoe
Total System Benefits (USD)	$604.70	$737.45
GHG Savings (metric tons)	-0.04 MT	0.80 MT

Summary of Findings

Design Innovation

- Compact, high-density PCM modules function as instantaneous water heaters for individual or grouped units
- 67% reduction in central storage volume
- Eliminated need for swing tank

Energy and Cost Savings

- 26% reduction in recirculation losses
- 8% reduction in total DHW load
- Upfront costs comparable to CHPWH upgrade with swing tank and load shifting capabilities

Technology Limitations

- Need for CHPWH that produce high supply temperatures with low delta T
- PCM materials with lower-melting point temperatures may expand opportunity

Conclusions and Next Steps

Project Conclusion

- Integrating distributed PCM TESS in central multifamily DHW systems represents a pathway for electrification in buildings where space constrained mechanical rooms are a barrier to electrification
- Final Report: ET25SWE0050_Phase Change Material Applications in Multifamily Water Heating_Final Report

Next Steps

- Two approved follow-up studies:
    - Development of modeling capabilities for PCM-integrated DHW systems
    - Field demonstration of distributed PCM system
- Present findings at ACEEE Hot Water Forum in March 2026

Thank You!

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Lab Test of a Variable Speed Multi-Function Heat Pump

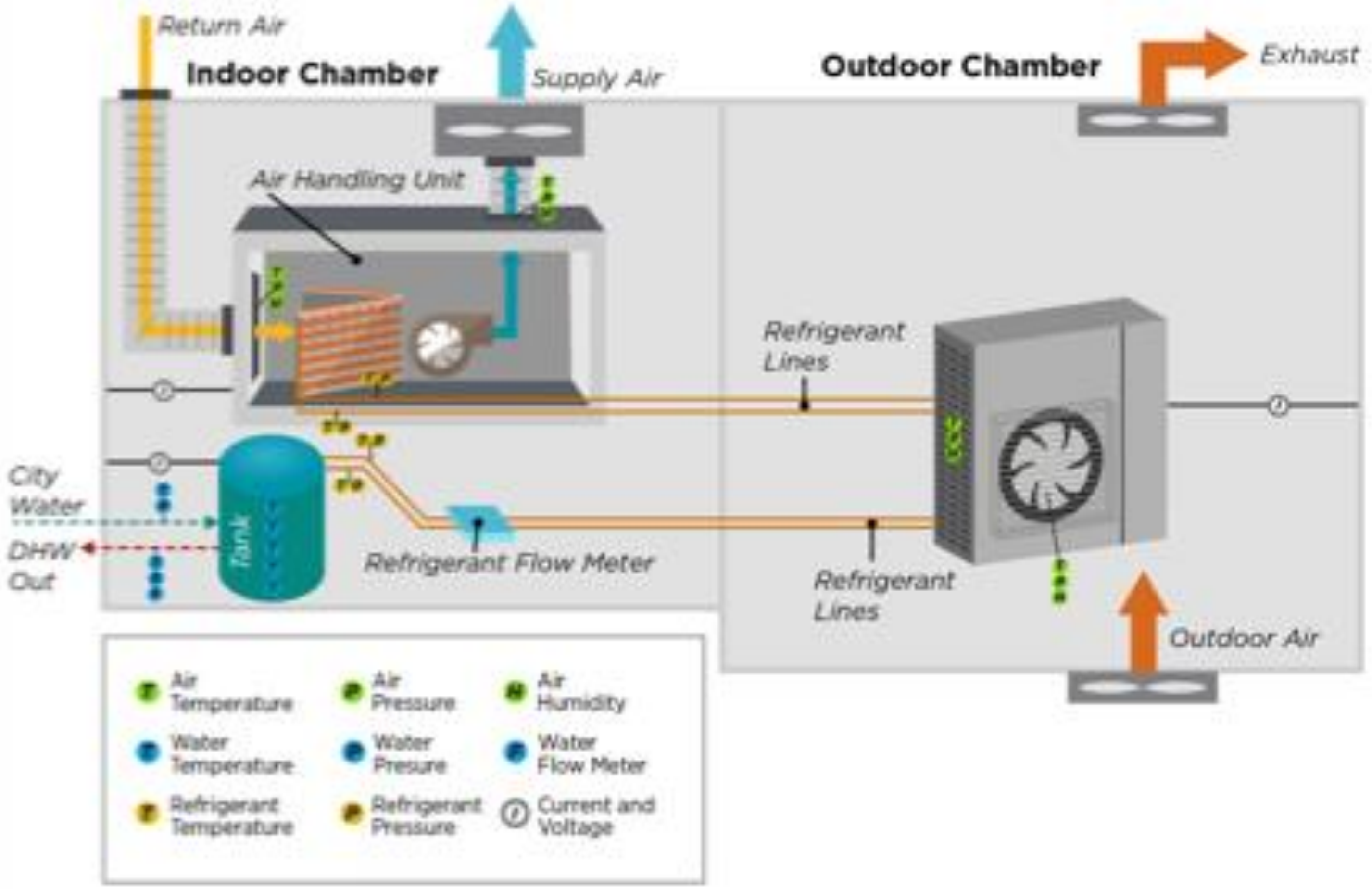
Project Outcomes and Tech Transfer

Fred Meyers
UC Davis Western Cooling Efficiency Center

Agenda

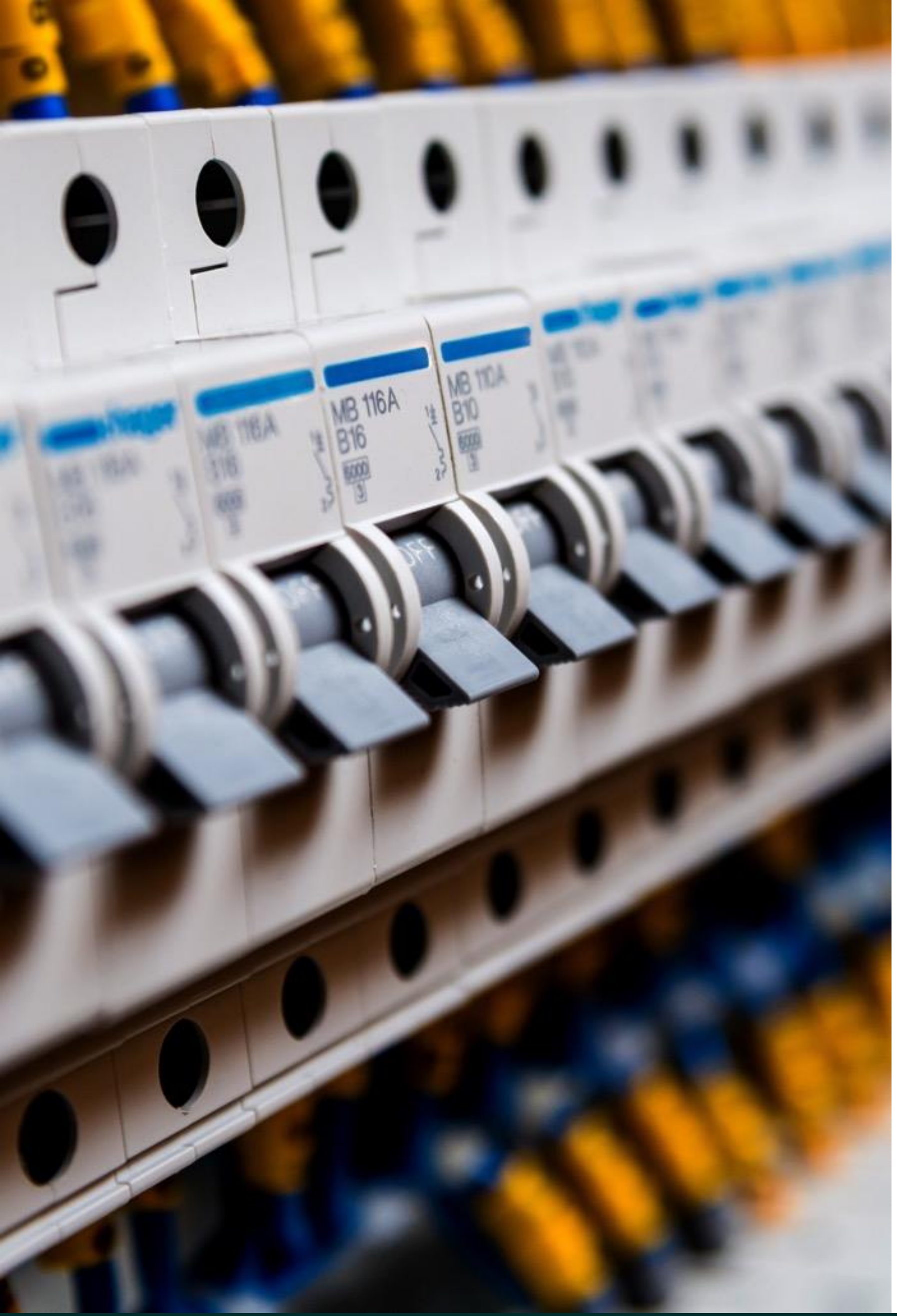
Lab Test of a Variable Speed Multi-Function Heat Pump (MFHP)

- Lab testing of residential MFHP in controlled environmental chamber
- Large test matrix across modes and conditions
  - Space cooling/heating
  - Combined space heating and hot water
  - Combined space cooling and hot water (heat recovery)
- Worked with manufacturer to facilitate development for California market



Project Purpose

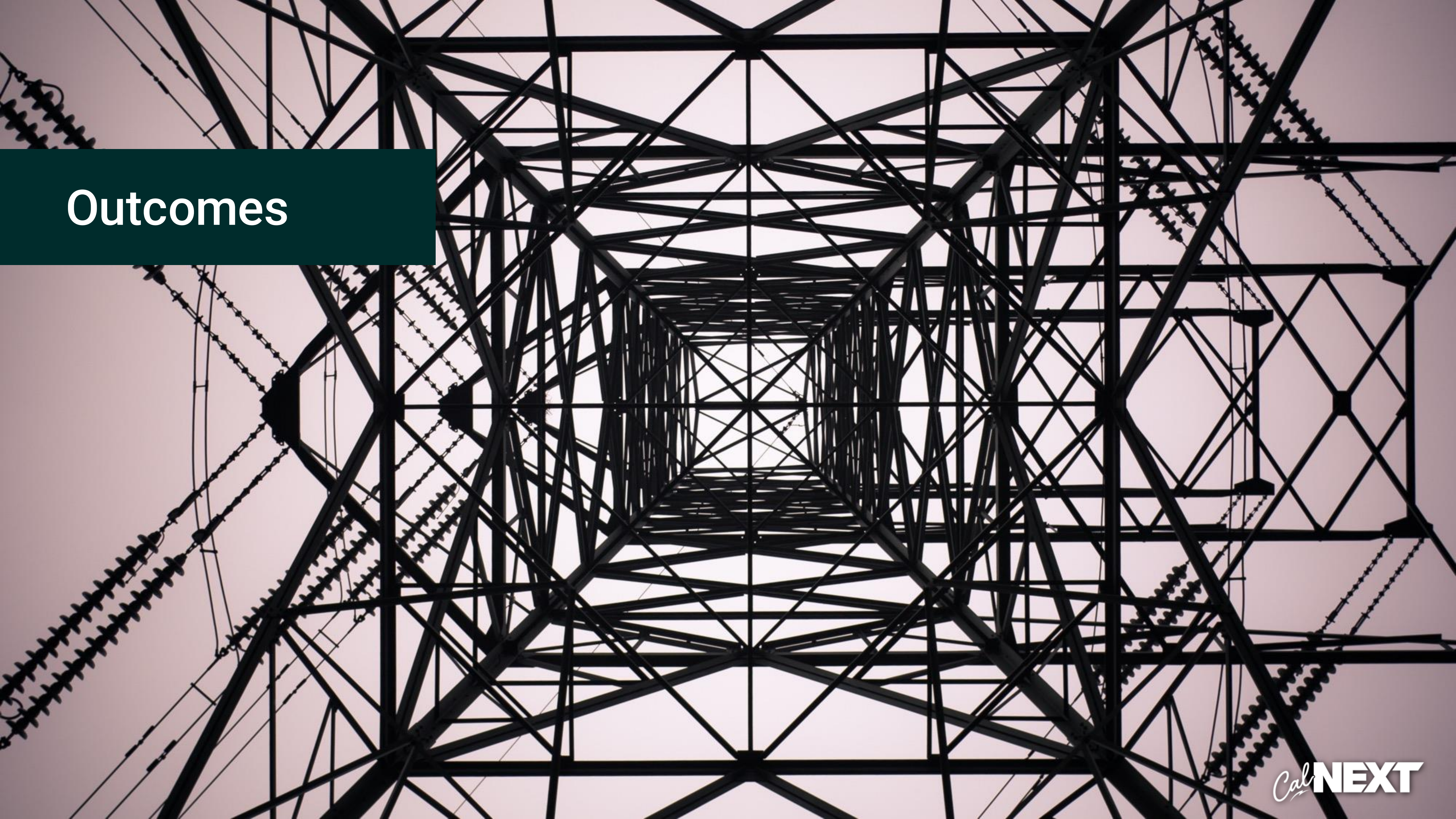
- Evaluate the performance of a variable-speed MFHP that provides space cooling, space heating, and domestic hot water from a single system
- Assess whether MFHPs can reduce peak electrical demand compared to conventional, separate systems
- Generate laboratory-validated performance data to support future modeling, measure development, and technology transfer in California



Stakeholders

- Compliance modeling developers (e.g. CBECC-Res team)
- Equipment manufacturer to refine the product and develop for California market
- California Technical Forum for future measure development
- CalNEXT partners for collaboration on measure development
- Met with investor-owned utility representatives from the codes and standards team. Advised on the current status of MFHP and future potential

Outcomes



MFHP Performance Summary

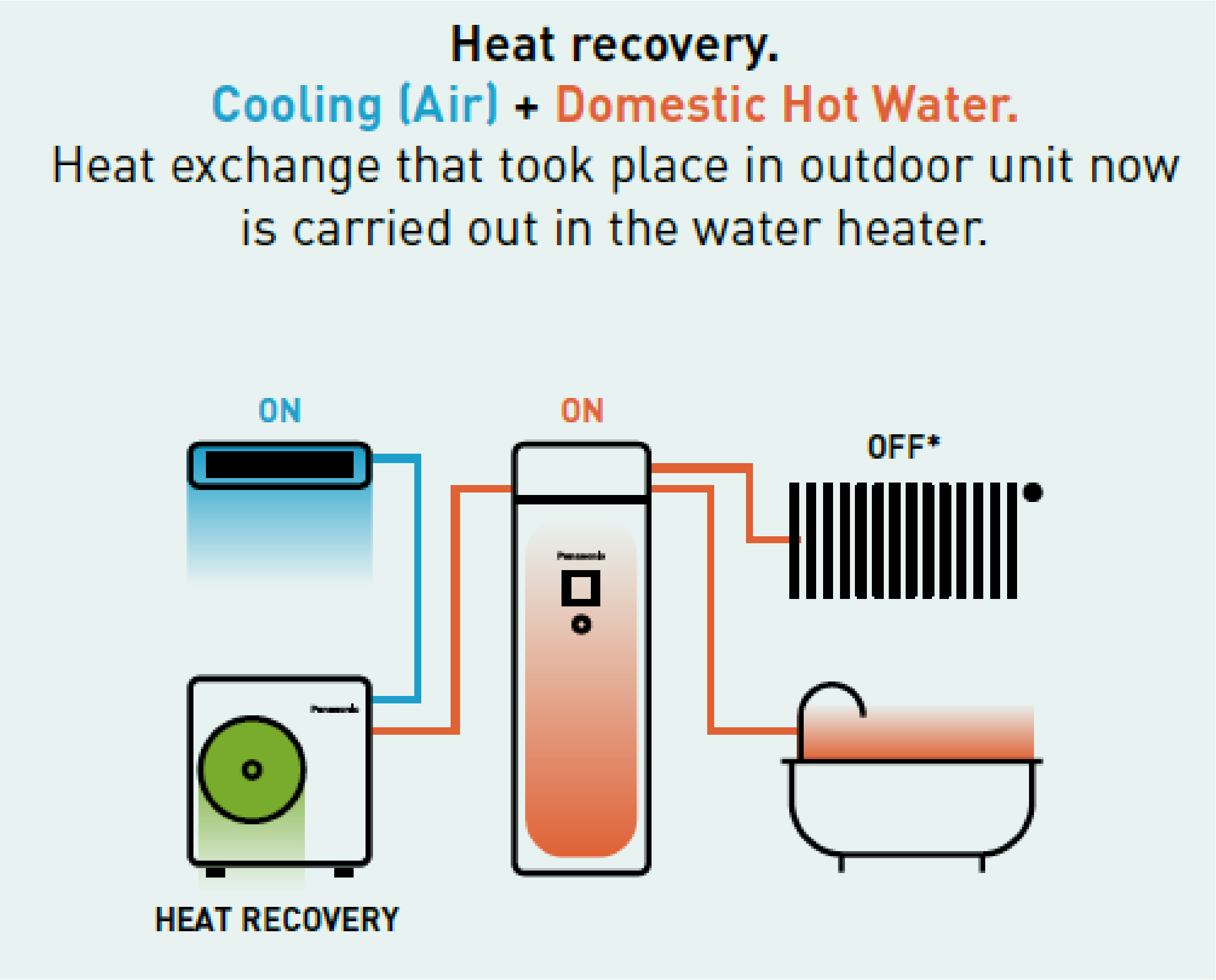
- Good Coefficient of Performance (COP) across range of conditions
- Water heating COP of 1.86 down to 17°F
- Very good heat recovery COP
- Ability to overspeed compressor for performance during extreme weather

Outdoor: 95DB Indoor: 80DB/67WB	Outdoor: 47DB/43WB Indoor: 70DB	Outdoor: 17DB/15WB Indoor: 70DB
Space Cooling COP: 3.42	Space Heating COP: 3.96	Space Heating COP: 2.49
Heat Recovery COP: 7.92	Bi-Heat COP: 3.36*	Water Heating COP: 1.86*

*Average tank temperature at 110°F

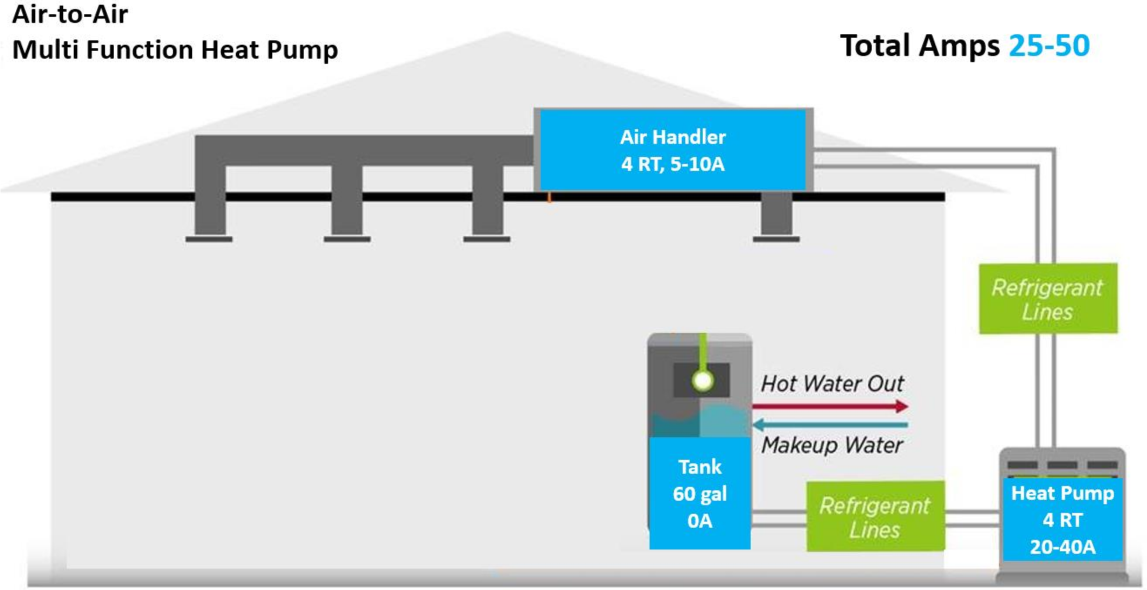
Panel size reduction opportunity

- Defrost cycle uses heat recovery from hot water
- No resistive backup heat for air handler or water heater.
- Peak defrost power of 3.18kw
- Heat recovery mode saved 33% on average compared to separate water heating and space cooling equipment



Summary of Findings

- Reduced electrification barriers
  - No backup heat needed for defrost
  - Less likely to need a panel upgrade
- High efficiency heat recovery mode reduced energy compared to separate systems
- Validated performance curves for EnergyPlus and CBECC-RES integration



Conclusions and Next Steps

Project Conclusion

- This project addressed the need for performance validation of air-to-air MFHP
- Benefits residential end users and promotes energy savings and electrification

Next Steps

- Performance verification of commercially available model ready for California market (in pre-draft plan stage)
- Investigate opportunities for DEER modeling

Thank You!

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Performance Evaluation of Advanced HEMS

Project Outcomes and Tech Transfer

Manuel Lopez

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Agenda

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3 Stakeholders

4 Savings

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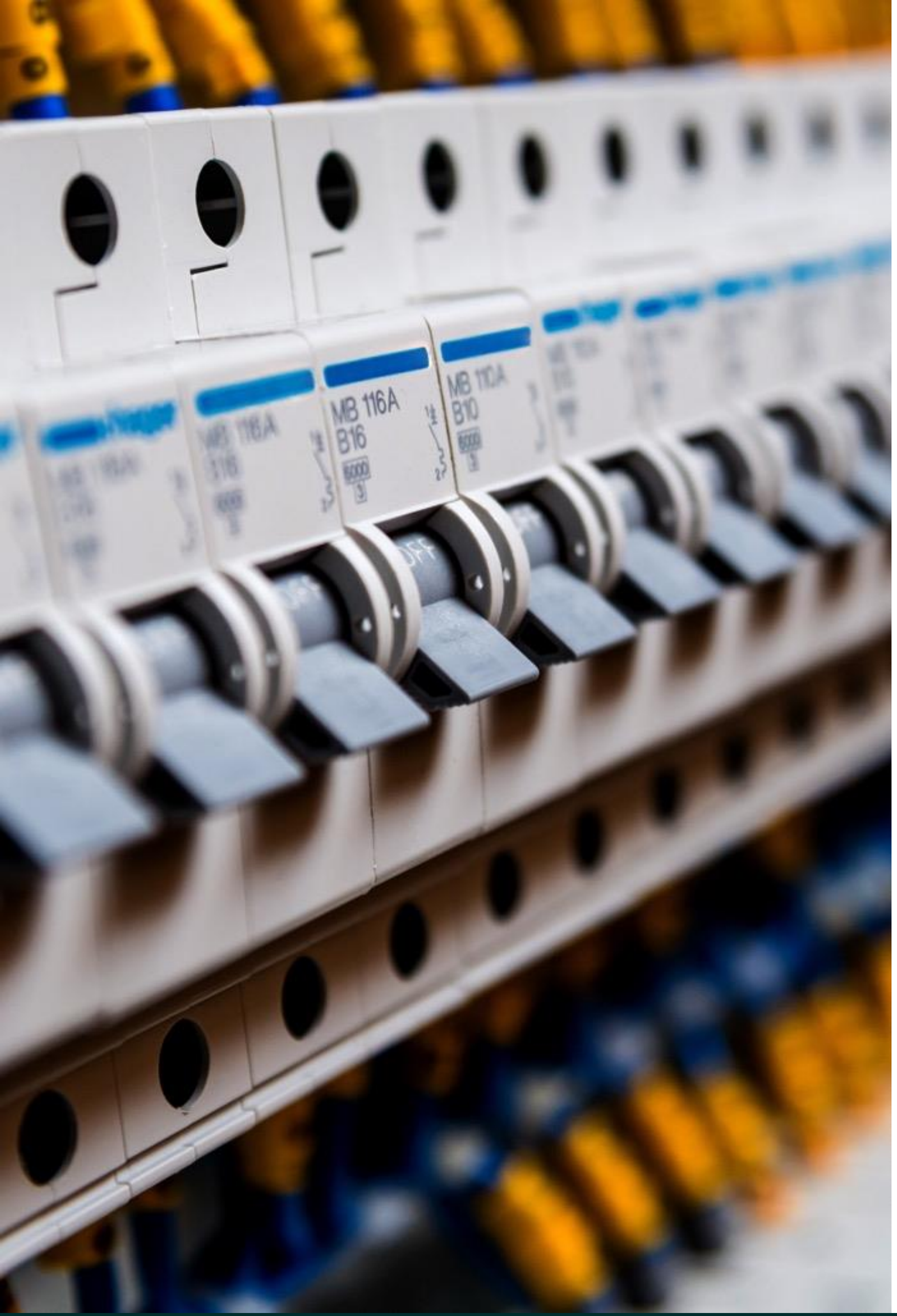
About Performance Evaluation of Advanced HEMS

- Evaluated advanced home energy management system (AHEMS) product types with varying integration capabilities and architectures
- Four systems were evaluated, including two AC-bus architectures and two DC-bus / V2X-capable platforms
- Conducted energy throughput testing across key transmission pathways (e.g., grid-to-battery, battery-to-grid, solar-to-battery, solar-to-grid)
- Performed event response testing using a 24-hour residential load profile to assess system behavior under dynamic conditions
- Applied time-of-use (TOU) rate structures to evaluate dispatch behavior and calculate energy cost and savings impacts

What Is Its Purpose?

- Quantify system performance across key metrics, including electrical efficiency, interoperability, and load flexibility
- Validate advanced home energy management system performance against manufacturer claims and expected operation
- Evaluate system response to dynamic operating scenarios, including load variation, distributed energy resources interaction, and grid events
- Compare system performance and energy impacts against typical residential load operation
- Provide actionable insights and recommendations to support utility programs, manufacturers, and market adoption

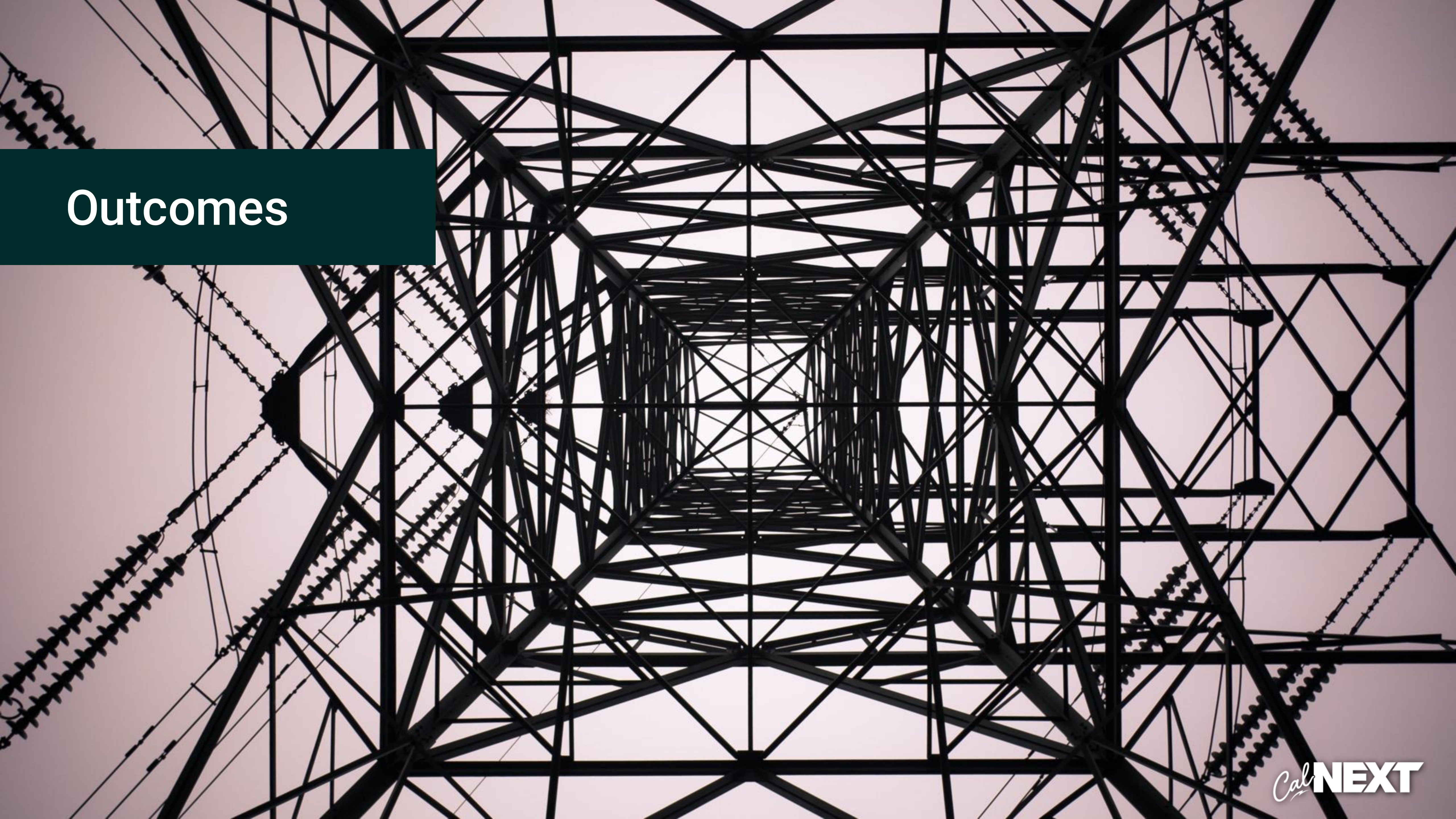


Stakeholders

Utilities and Program Administrators: inform program design, rate structures, policy alignment, and grid-interactive load management strategies

Manufacturers: refine control logic, system integration, and product performance based on laboratory findings

End Users: assess potential for energy cost savings, resiliency, and optimized use of DERs (solar, storage, EVs)



Outcomes

Summary of Findings

- AHEMS demonstrated consistently high electrical efficiency across tested pathways, with measured values, generally ranging from about 90–99%
- System architecture affected readiness for evaluation, with the two AC-bus systems completing testing while the two DC-bus / V2X-capable platforms were not ready for full assessment
- System value is primarily driven by control logic, not hardware efficiency
- TOU-optimized systems can deliver meaningful cost savings and emissions reductions when dispatch aligns with rate structures
- Fixed or poorly implemented control strategies can result in counterproductive operation and reduced economic benefit

Summary of Savings

24-Hour Test Period

- PG&E TOU rate profile
- Loading profile based on RASS single-family dwelling
- Import and export values based on E-ELEC Nem 3.0 rate structure

Net Annual Benefit : $1,492

AHEMS 2 – PG&E E-ELEM NEM rate	Daily Grid Import	Daily Grid Export	Daily Net Benefit
Winter Season	31.27 kWh - $10.87	42.18 kWh - $14.90	**$4.03**
Summer Season	31.27 kWh - $14.00	42.18 kWh - $19.69	**$5.69**

*Source: CLTC

Conclusions and Next Steps

Project Conclusion

- Demonstrates advanced home energy management systems as enabling technologies for integrated DERs control, load flexibility, and grid-interactive efficient buildings (Whole Buildings TPM)
- Provides end users with a pathway to achieve energy cost savings, improved load management, and reduced greenhouse gas emissions through coordinated control of solar, storage, and loads
- Identifies the need for improved control strategies and system validation to ensure technologies deliver expected efficiency, load flexibility, and grid benefits in real-world operation

Next Steps

- Continue tracking development of DC-bus architectures and bidirectional EV (V2X) systems to assess their potential for increased energy savings, load flexibility, and grid benefits.
- Conduct future laboratory and field evaluations of these systems to quantify performance, interoperability, and control capabilities.

Thank You!

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Field Demonstration of Electric Clothes Dryer Controller

Project Outcomes and Tech Transfer

CalNEXT ENERGIZING CALIFORNIA'S FUTURE

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Agenda

1 Project Summary

2 Baseline and Proposed Updates

3 Identified Stakeholders

4 Savings

5 Next Steps

About Field Demonstration of Electric Clothes Dryer Controller

Project Summary

This study tested an add-on electric dryer controller that stops drying based on exhaust temperature and humidity. 10 electric dryers were monitored in DAC.

Key Findings

(average of field test)

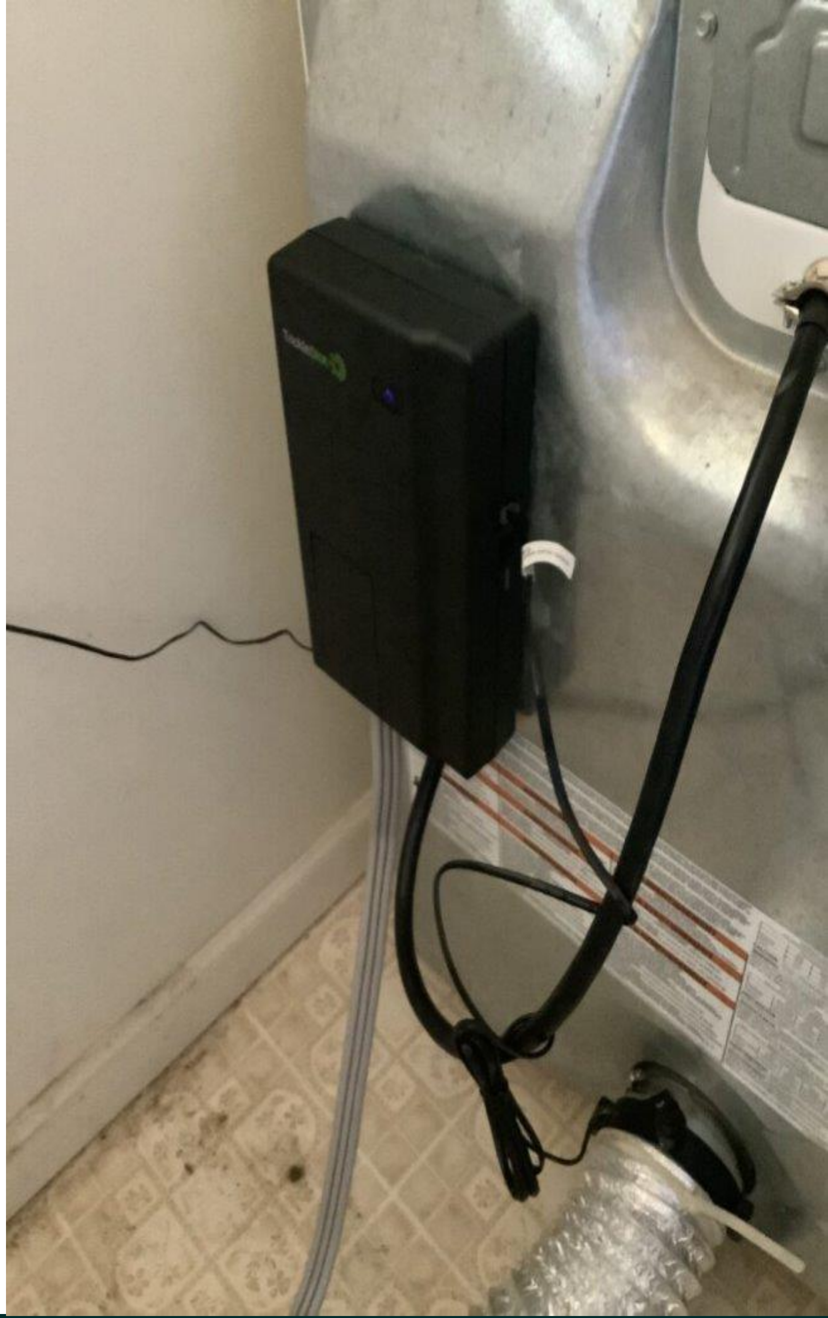
Energy Savings: 19.4% less energy per cycle

Cycle Time: 15.8% shorter drying duration

GHG Reduction: 53–88 kg CO_2e per dryer annually

User Feedback: 78% noticed faster drying; 100% satisfied with dryness

Cost Effectiveness: Simple payback of 4–6.6 years w/o incentives



Purpose

This field demonstration assessed the performance and energy-savings potential of an add-on electric clothes dryer controller installed in ten California homes in Climate Zone 12, located in disadvantaged communities.

Questions answered by the project

- Energy and greenhouse gas savings
- User satisfaction and operational impacts
- Adoption barriers to inform future measure development

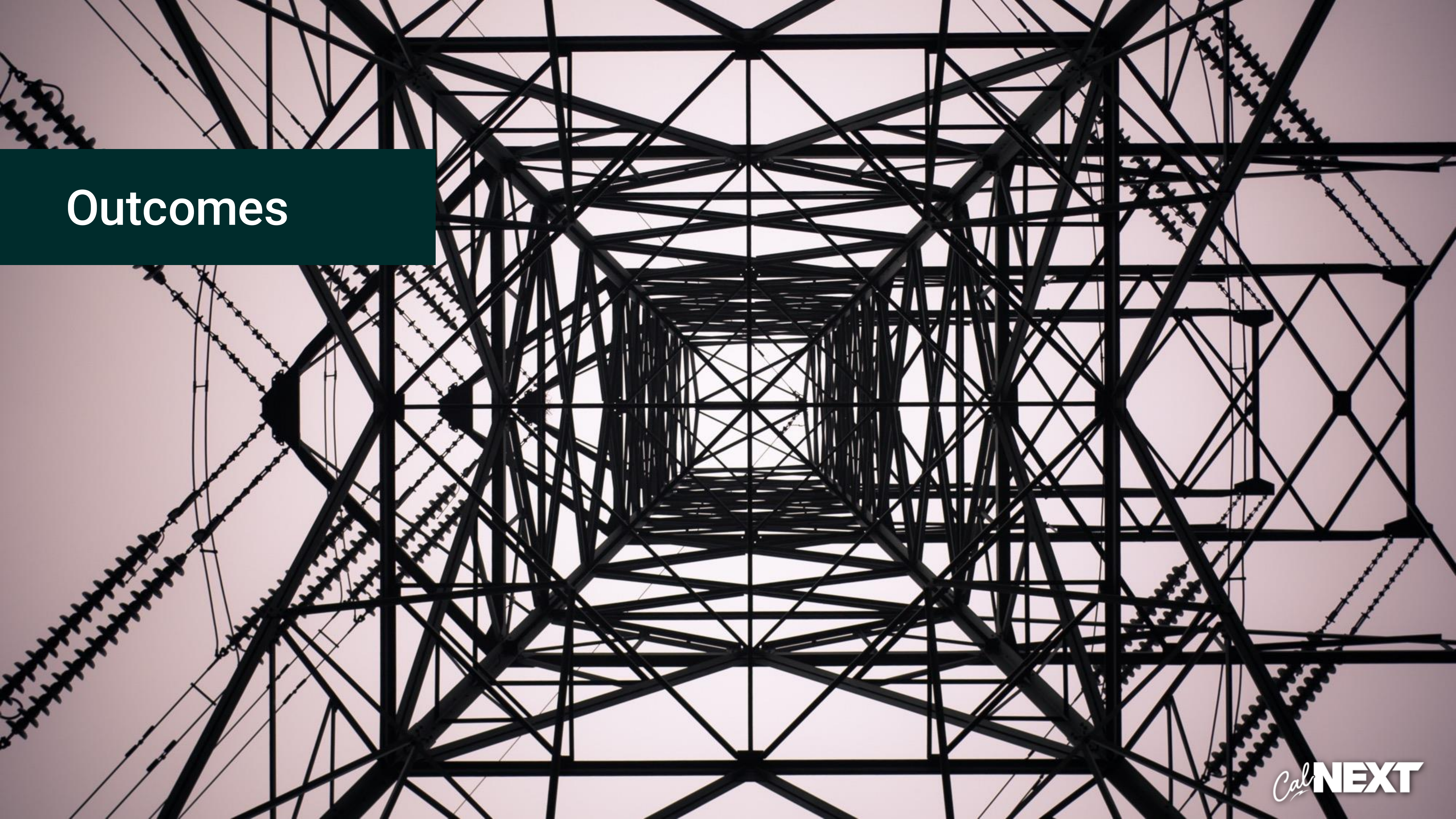
Baseline equipment of the project

Existing electric clothes dryer that uses a thermistor and or a contact type humidity sensor to check clothes dryness.

- Rated voltage : 240V
- Rated AC current: 25 amps max

Stakeholders

Stakeholder Category	Organization Name	Contact Name or Title	Feedback and Recommendations
California Program Administrator	CalNEXT program team	CalNEXT program team	The Program Team provided feedback on the project scope during the screening and scanning phase of the project. The feedback and recommendations were incorporated into the project scope.
California Program Administrator	Southern California Edison	Reviewer	SCE provided feedback on all our project deliverables, including the Project Plan, Preliminary Findings Report, Draft Report, and Final Report. All feedback was addressed in the Final Report.
Original Equipment Manufacturer	Manufacturer (Anonymized)	Anonymous	The project team gathered feedback from the technology manufacturer on an ongoing basis. They were knowledgeable about the technology, installation, operation, and performance of the technology.
Host Site Customers	Homeowner 1 to 10	Anonymous	The project team gathered feedback from the host customers during the project period. They provided feedback on technology installation, usability, and dryer performance.
Installation Contractor	Synergy Companies	David Price Lyal Ray	The installation contractor provided valuable feedback on cost, tools, safety, and installation ease, which refines the future directions.



Outcomes

Summary of Savings

Criteria	Initial Cost	Installation Cost	Total Cost	Savings per Year	Cost Savings per Year*	EUL	Simple Payback
Actual number of cycles	$150	$200	$350	220 kWh	$88.0	4.0 years	4.0 years
Standard number of cycles	$150	$200	$350	133 kWh	$53.2	4.0 years	6.6 years

If installation cost would be incentivized

Criteria	Initial Cost	Installation Cost	Total Cost	Savings per Year	Cost Savings per Year*	EUL	Simple Payback
Actual number of cycles	$150	$0	$150	220 kWh	$88.0	4.0 years	1.7 years
Standard number of cycles	$150	$0	$150	133 kWh	$53.2	4.0 years	2.8 years

*$0.40/kWh

Summary of Findings

Measure package design

1. TSB analysis would help focus better savings potential
2. Incentive design for the DAC/HTR community with full incentive
3. Incentive design for existing residential customers with installation incentive
4. Rebate design as add-on equipment with a new electric dryer, which will reduce the installation cost and increase cost effectiveness.

Product improvement

The team also recommended product improvement (plug and play design with wireless sensor) to ease installation, reduce installation cost, and address demand response (CTA 2045/EcoPort integration).

Customer Awareness

Encourage customers not to use electric clothes dryers during the peak period, addressing demand response.

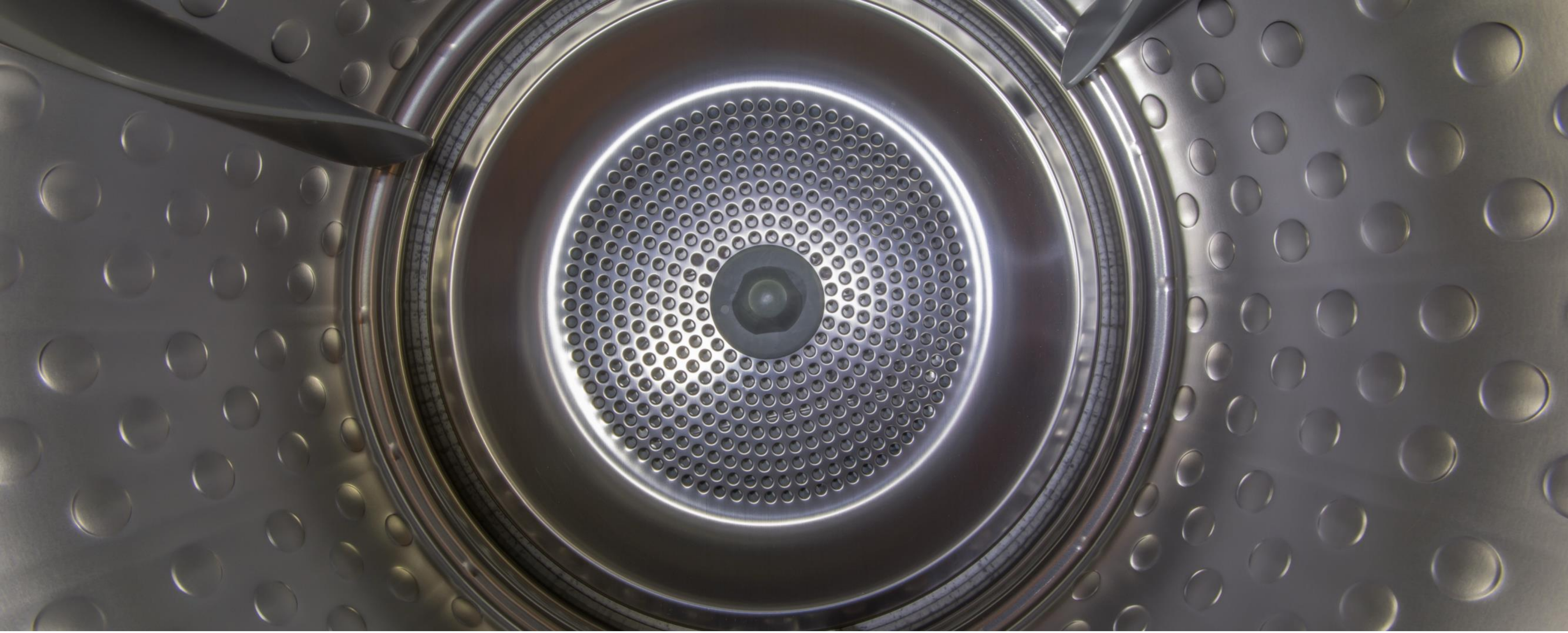
Conclusions and Next Steps

Project Conclusion

- This project has addressed the 2023 Plug Loads TPM enhancing our understanding of the potential energy savings achievable through optimized plug load.
- End users will have better clothes drying experience and savings on electric utility bills.
- Develop workpaper based on a larger field study followed by measure package development.

Next Steps

- Program design: Promote early adoption through utility program incentives, with a focus on reaching disadvantaged communities.
- Measure development: Expand the sample size to support the development of deemed and custom measures for program evaluation.
- Demand response integration: Integrate the technology with demand response programs to shift dryer usage away from peak periods and support grid reliability.



Thank You!

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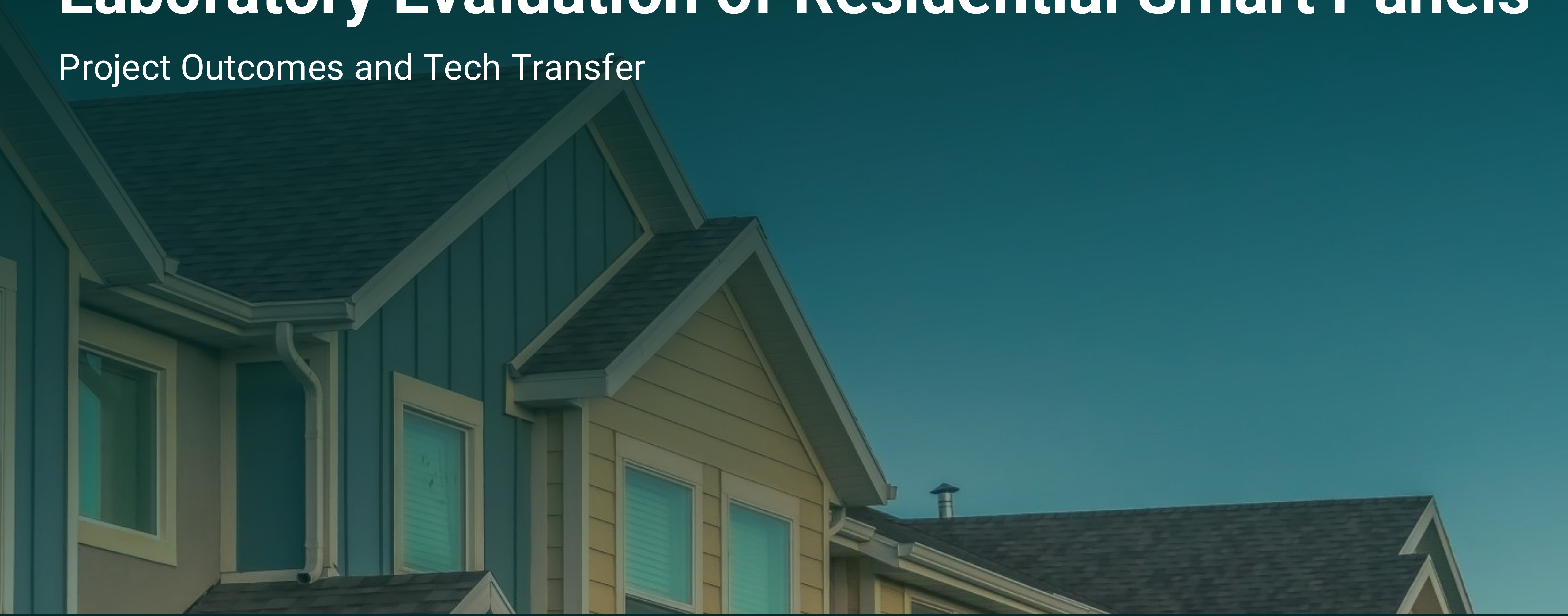
Laboratory Evaluation of Residential Smart Panels

Project Outcomes and Tech Transfer



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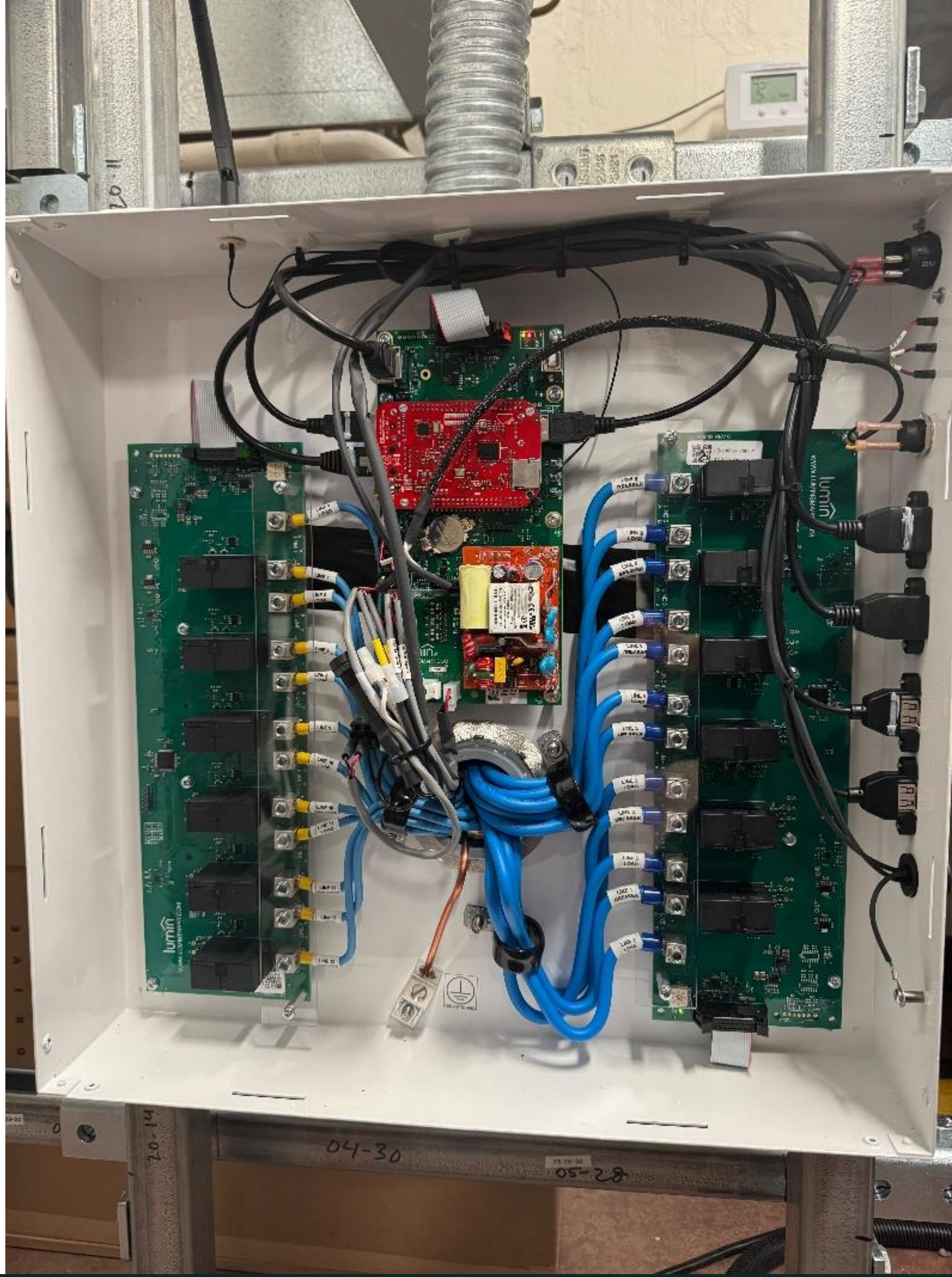
Agenda

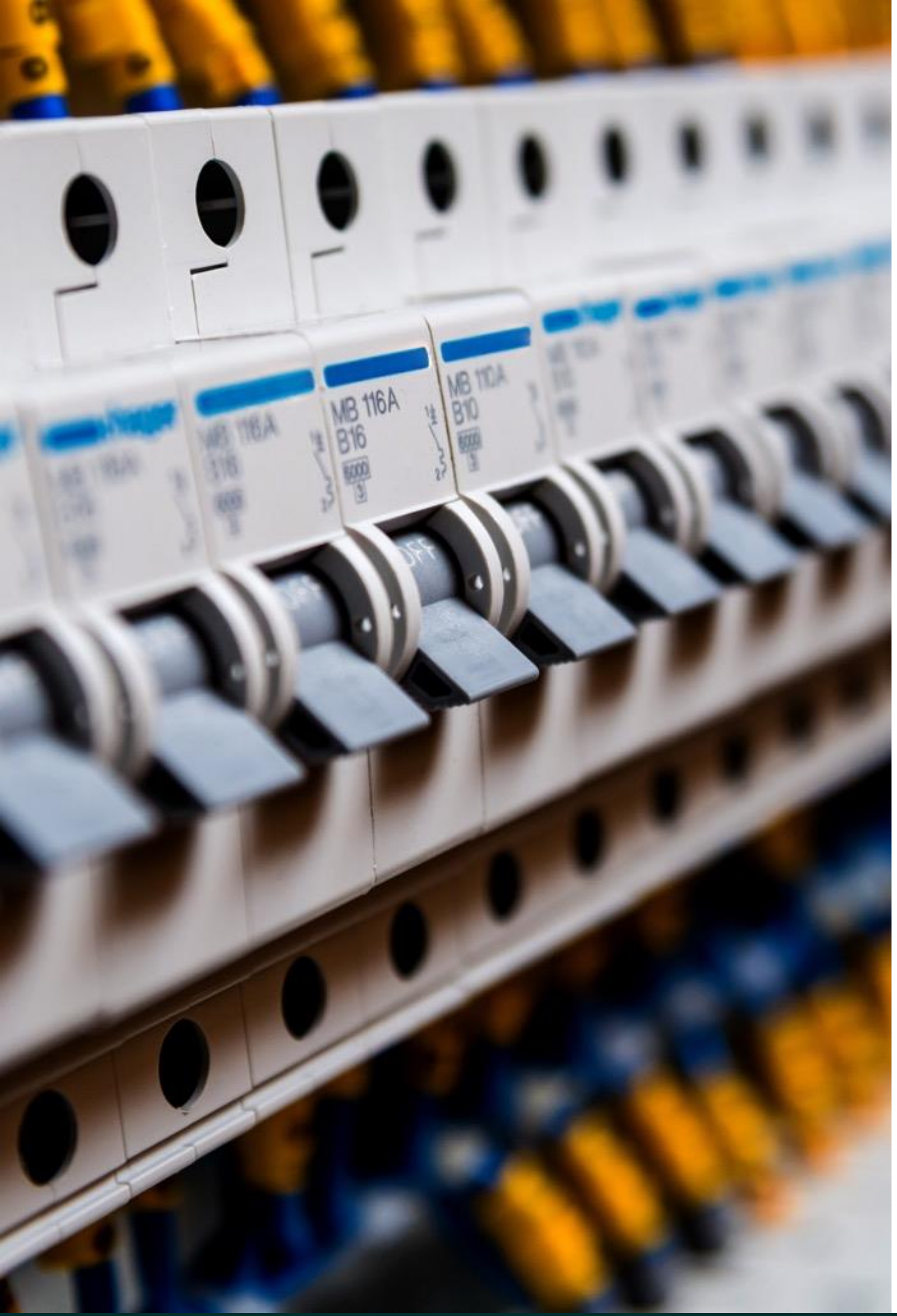
About Laboratory Evaluation of Residential Smart Panels

- Evaluated residential smart panel technologies for energy efficiency, electrification, and service upgrade avoidance
- Tested Three Systems: Smart Panels, Smart Subpanels, Smart Breakers
- Conducted controlled lab testing under simulated loads to assess load shed response behavior
- Verified circuit level metering accuracy of smart panel products
- Identified key market barriers including cost, stakeholder familiarity, code/regulatory hurdles

Project Purpose

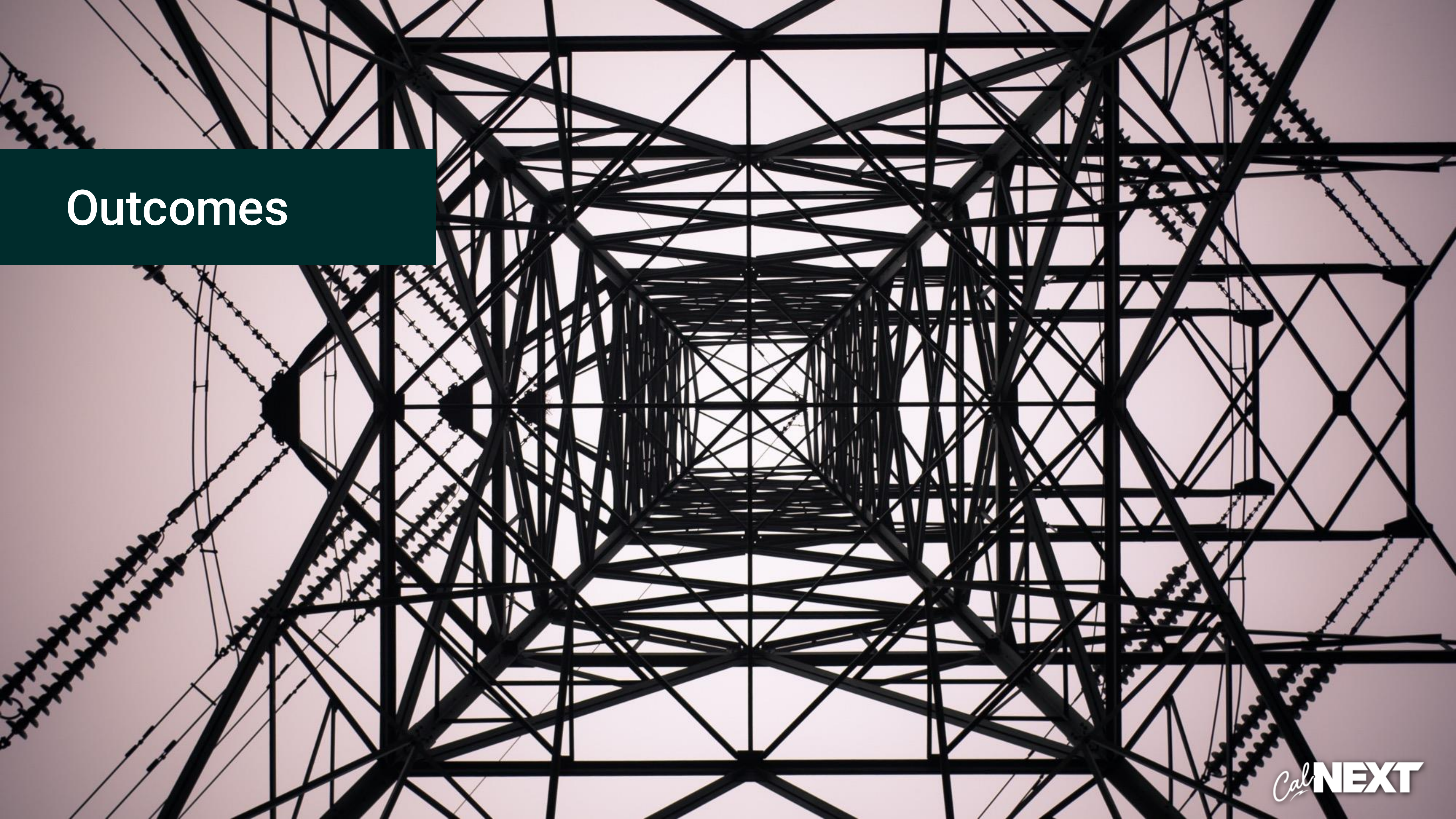
- Residential electrification is constrained by limited service capacity and high upgrade costs
- Smart panels proposed as an alternative to enable electrification without infrastructure upgrades
- Lack of independent validation on safety, performance, and real-world functionality of these systems
- Uncertainty around whether marketed capabilities are technically mature
- Need to assess market readiness, including contractor adoption and code/inspection alignment





Stakeholders

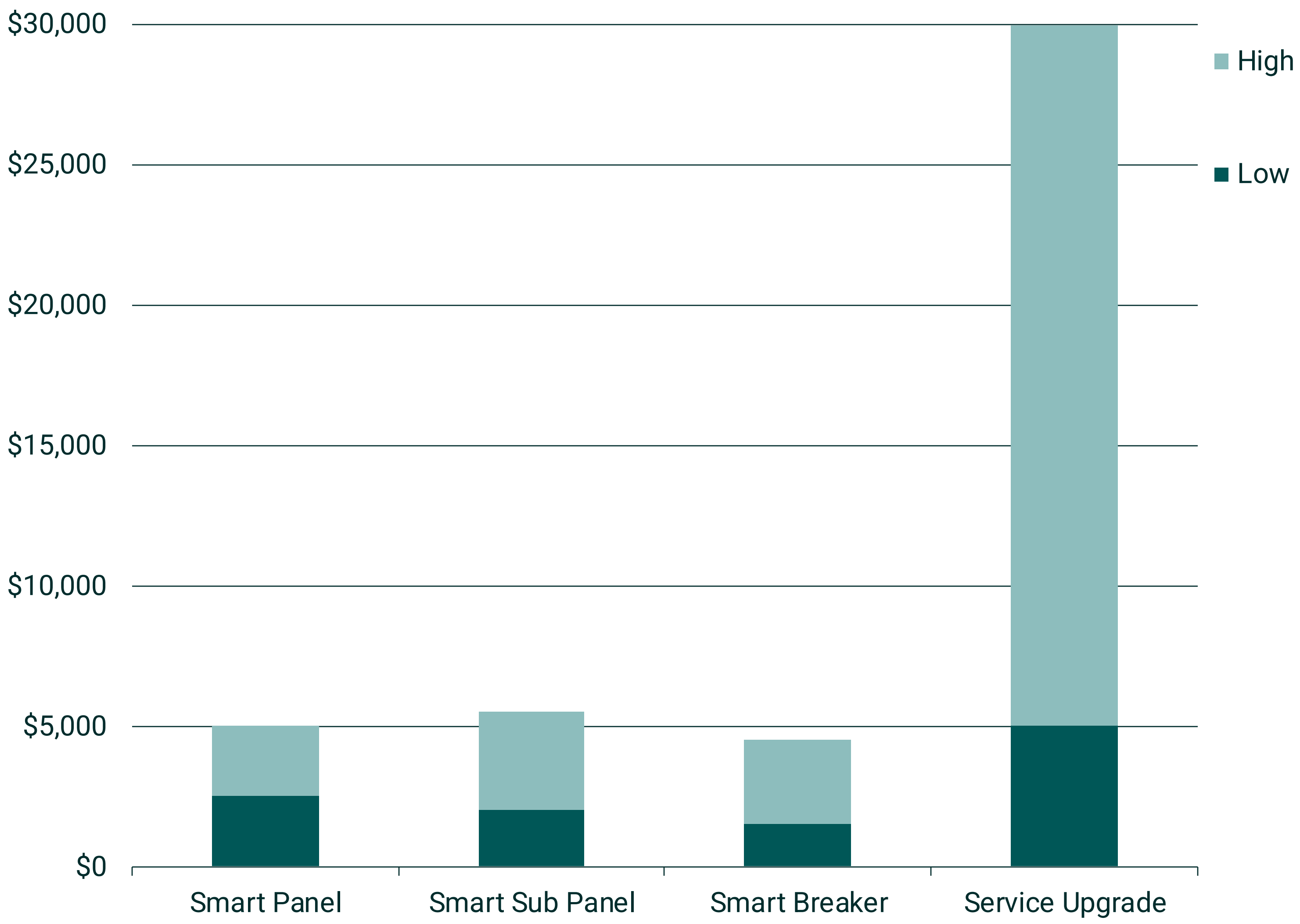
- **Utilities and Program Administrators:** inform program design, incentives, and load management strategies
- **Manufacturers**: refine product design, controls, and feature development based on performance gaps
- **Electrical Contractors**: understand installation complexity, training needs, and market opportunity
- **Code Officials and Inspectors:** evaluate code compliance, inspection processes, and safety considerations
- **Homeowners:** assess viability of avoiding service upgrades and enabling electrification



Outcomes

Summary of Savings

- Primary value is capital cost avoidance
- Avoided upgrade costs can be substantial (panel, service drop, transformer impacts)
- No measurable energy savings from efficiency improvements under tested conditions
- No demonstrated demand response or dynamic load optimization capability



Summary of Findings

- Smart panels successfully perform load shed and can defer service upgrades under real load conditions
- System behavior varies meaningfully by architecture (automatic load shed vs. scenes)
- Current products lack mature native controls (limited demand response, energy efficiency features, scheduling)
- Metering is sufficiently accurate for consumers but not revenue-grade
- Market barriers (cost, training, inspection transparency) are as limiting as technical performance

Conclusions and Next Steps

Project Conclusion

- Demonstrates viability of service upgrade avoidance to support electrification within existing residential electrical infrastructure (Whole Buildings TPM)
- Provides end users a pathway to adopt high-load electric technologies while avoiding costly and complex service upgrades

Next Steps

- Advance control capabilities (demand response, DER integration), and support tech transfer through standards development, workforce training, and utility program alignment

Thank You!

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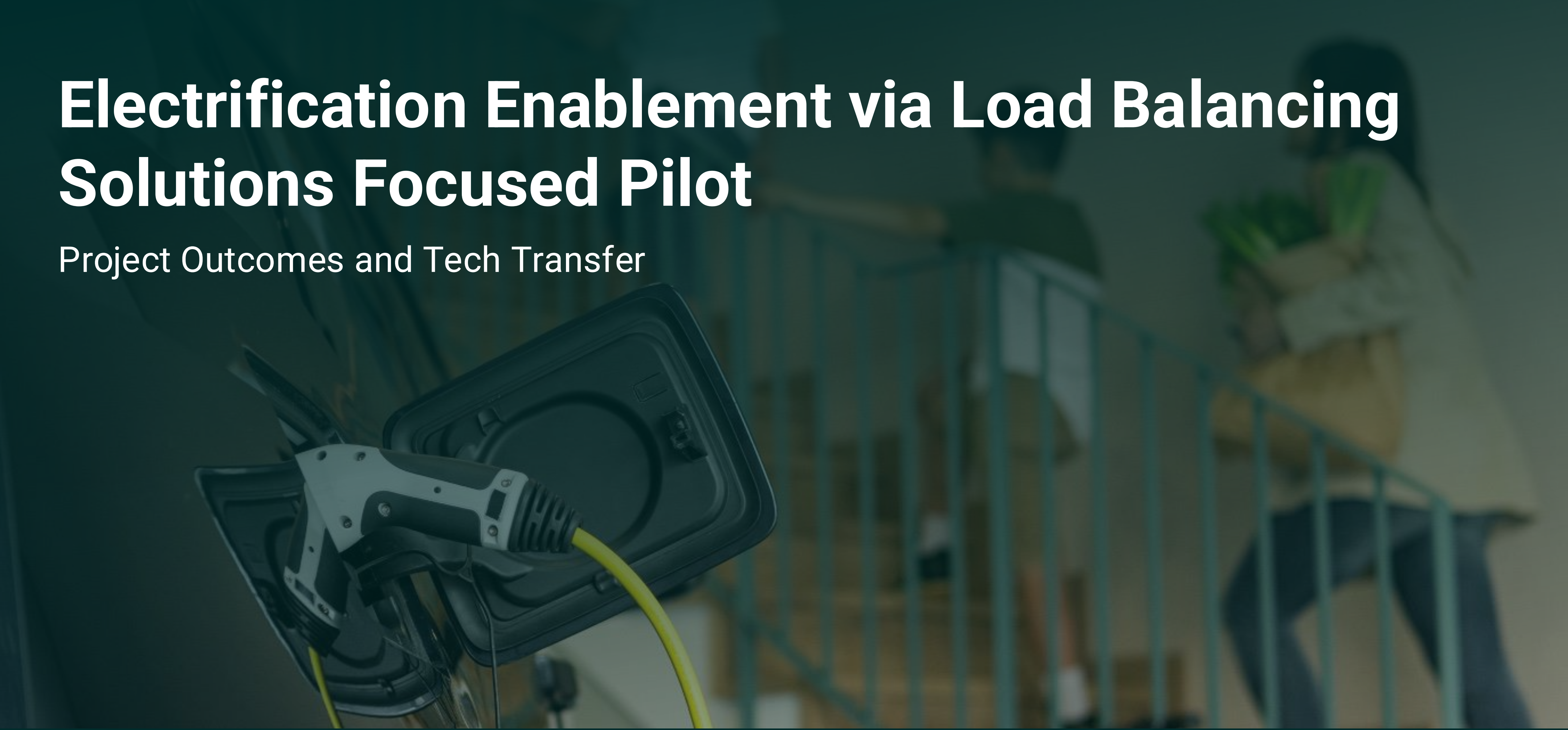
Electrification Enablement via Load Balancing Solutions Focused Pilot

Project Outcomes and Tech Transfer



CalNEXT
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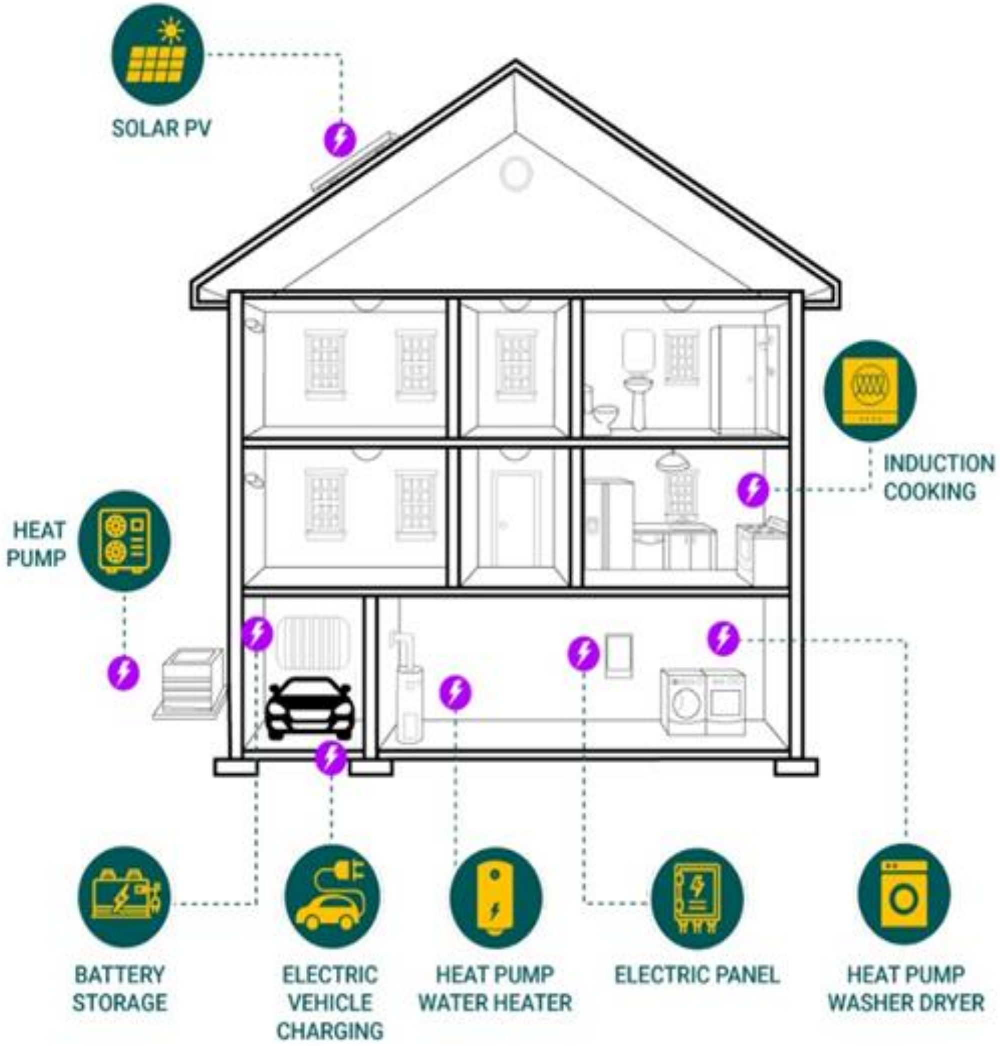
Amruta Khanolkar
Srushti Koli

Agenda

Electrification Enablement via Load-Balancing Solutions Focused Pilot

Pilot Objectives and Summary

- To understand how load-balancing solutions (LBTs) were being used in electric vehicle supply equipment (EVSE) installations and to validate potential and enable additional electrification without requiring costly electrical panel or service upsizing
- Covers a wide spectrum of technologies including circuit splitters, meter collars, smart panels, and smart circuit breakers
- Key outcomes include technology performance findings, integration challenges, and practical recommendations for contractors, customers, and program implementers for cost effective electrification



Baseline and Changes

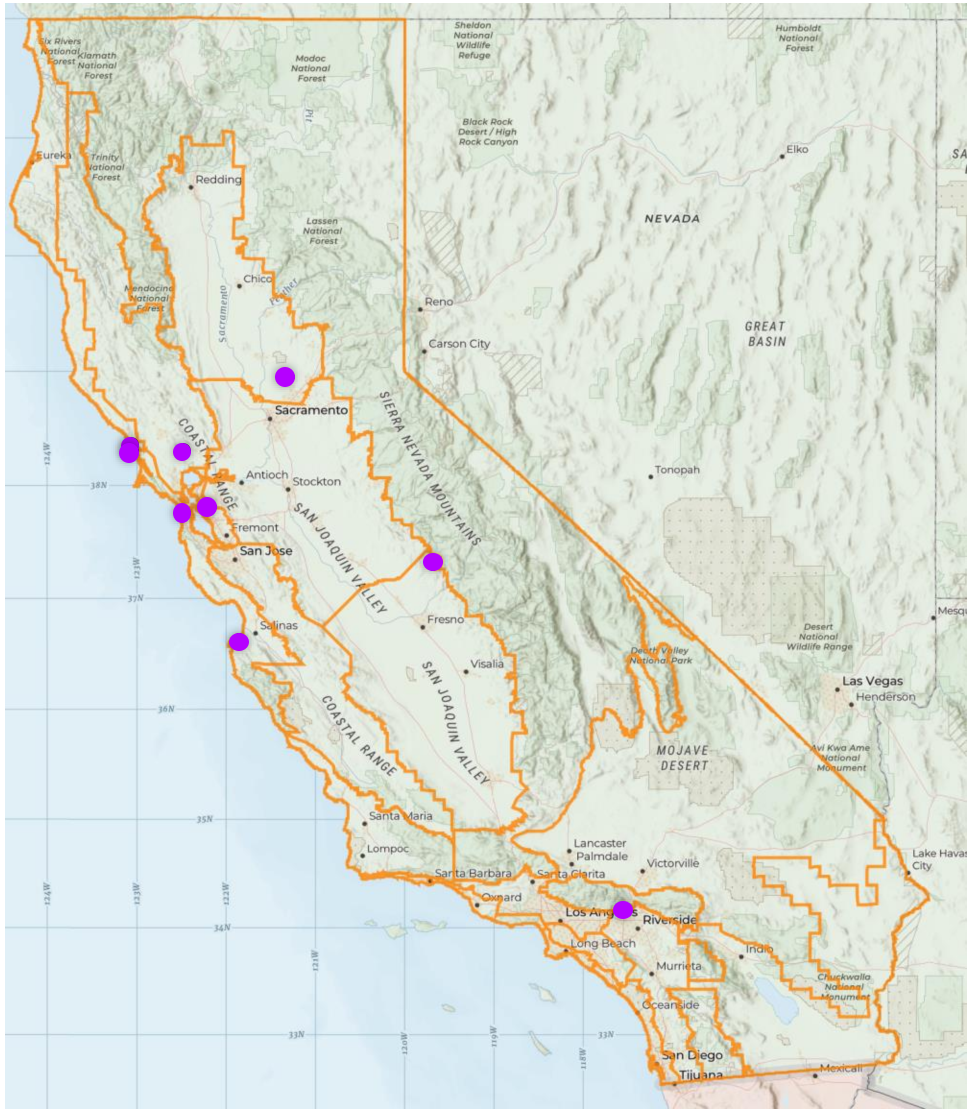
Baseline

Existing residential homes with gas fired appliances like water heaters, furnaces, clothes dryers with or without EV chargers and limited panel capacity.

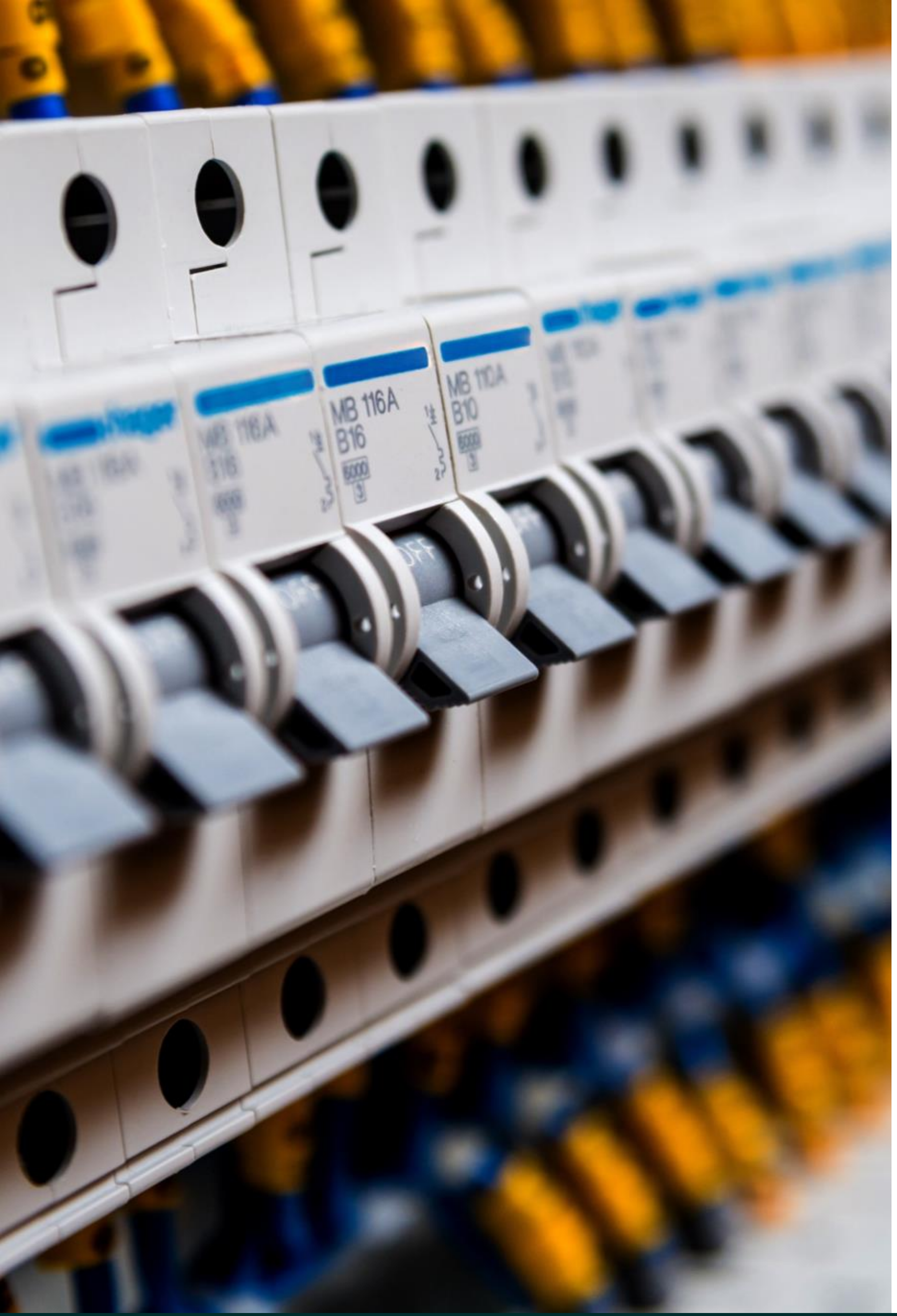
Proposed updates

- Electrified of gas fired appliances – heat pump water heaters (HPWHs), heat pump clothes dryers, HVAC HP, induction ranges
- Added Level 2 EV chargers for some homes
- Maintain homes under the service limit with installed LBTs

Focus Pilot Site Information



Site ID	LBT installed	Electric Appliance Installed	Loads Controlled by LBT
Site 1	Plug-in Circuit Splitter	HPWH, HVAC HP, Level 2 EV charger	HPWH, Level 2 EV charger
Site 2	Smart panel	Induction range, Level 2 EV charger	Induction range, EV charger, electric clothes dryer
Site 3	Smart panel	HPWH	All loads connected to the main panel
Site 4	Smart panel	HPWH	All loads connected to the main panel
Site 5	Smart subpanel	Induction range, Level 2 EV charger	Induction range, EV charger
Site 6	Smart subpanel	Induction range, Level 2 EV charger	Induction range, EV charger
Site 7	Smart subpanel	HPWH	EV charger, stove, hot tub, HVAC, dryer, heater, dishwasher and fridge
Site 8	Smart breaker	Level 2 EV charger, electric space heaters	EV charger 1, EV charger 2, HPWH, Electric space heaters, Hot tub, HVAC, Pool pump
Site 9	Smart breaker	Heat pump water heater, Heat pump clothes dryer	HPWH, Range (future), HVAC, HP clothes dryer
Site 10	Smart breaker	Heat pump water heater	EV charger



Stakeholders

Project Partners

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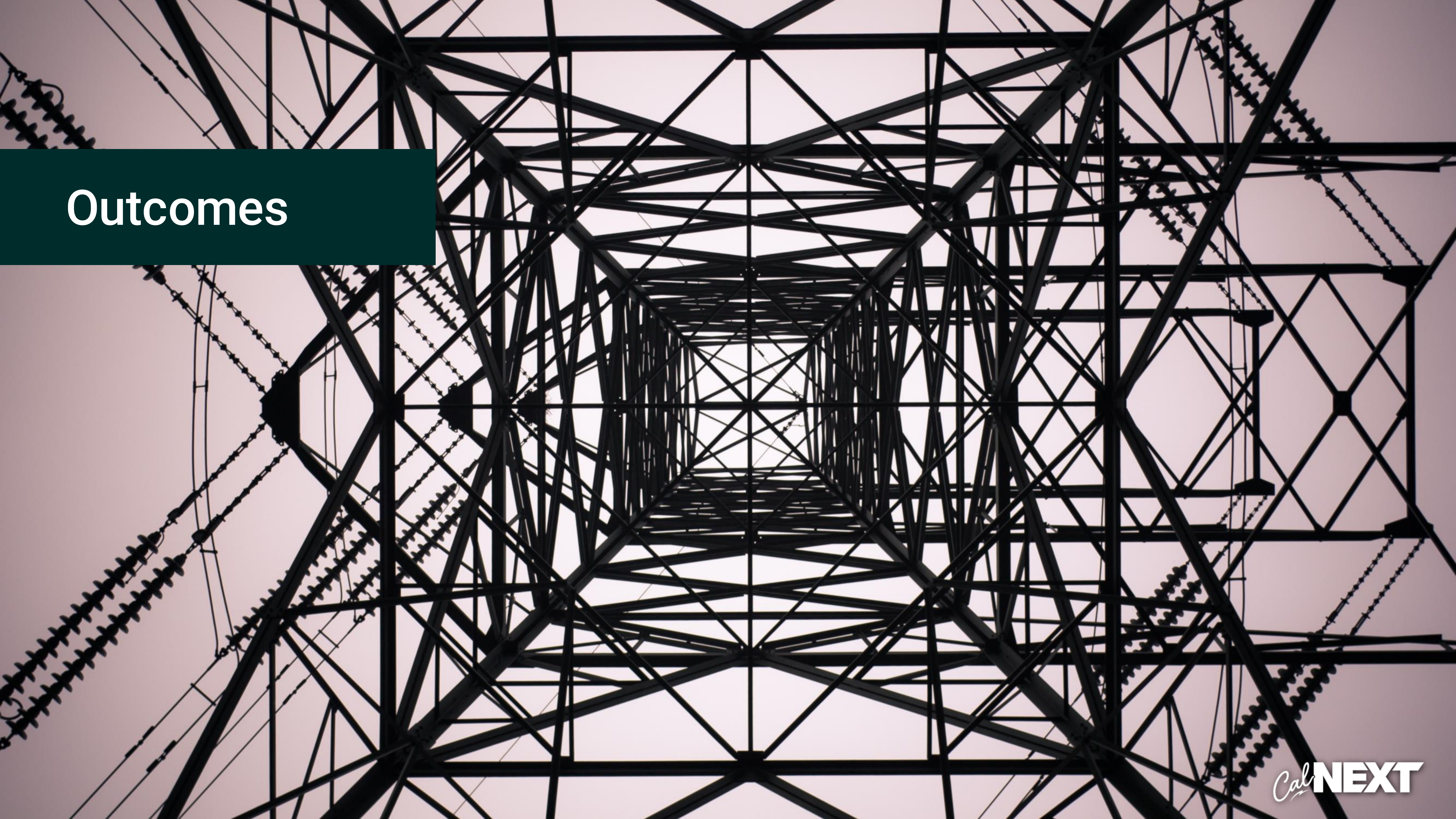
Outcomes



Summary of Impacts

Site	Existing Service Capacity (A)	Total Service Load (A)					
		Baseline	Baseline + EV	Baseline + EV + Pilot Electrification w/o LBT	Baseline + EV + Pilot Electrification w/ LBT	Baseline + EV + Full Electrification w/o LBT	Baseline + EV + Full Electrification w/ LBT
1	100	69.8	103.2	111.0	102.7	137.9	131.4
3	100	65.1	115.1	122.9	62.2	154.6	80.8
4	125	67.4	107.4	115.2	55.7	142.3	78.5
7	100	88.6	128.6	136.4	59.7	155	78.3
8	200	74.7	140.7	155.9	59.1	234.3	72.1
9	100	58.5	90.5	104.2	86.3	166.4	93.5
10	200	80.6	120.6	135.1	95.1	194	125.3

NEC load calcs (220.83) would likely require service upgrades
Explore alternative methodology like 220.87

Summary of Findings

- LBTs can help achieve cost effective and scalable electrification of retrofits
  - Electrified one to three end uses with Level 2 EV charging using LBT without need panel/service up sizing
  - LBTs cost $600 to $7,500, panel/service upsizing could cost $30,000+
- LBTs successfully maintain the total system draw under the threshold (verified through pilot demonstration)
  - Circuit Splitters – Pause secondary load when primary load exceed threshold
  - Smart Breakers – Sheds load with max power draw when panel threshold exceeds setpoint
  - Smart Panels/Sub Panels – Sheds load based on priority when panel threshold exceeds setpoint
- No barriers in current codes to install LBTs. Load sharing possible with EMS
- Smart breaker, smart subpanel, circuit splitter (hard wired or plug-in) do not require permits. Smart panel and meter collar need permits

Conclusions and Next Steps

Project Conclusion

- Whole Building, Portfolio Enhancement and Plug Loads and Appliances TPM
- Benefits to end users
    - **Homeowners:** Cost effective electrification and fuel switching benefits
    - **Contractors:** Awareness of alternative approaches to service upsizing
    - **Utilities:** Infrastructure upgrade avoidance possibilities
- Phase 2 pilot to demonstrate a potential program design

Next Steps

- 2026 ASHRAE Decarbonization Conference Seminar Presentation (confirmed)
- 2026 ACEEE Summer Study Informal Session (TBD)
- 2026 ET Summit (TBD)

Thank You!

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Thank You!

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