Unlocking the Value of Smart Panels

The Benefits of a Utility Ownership Model for Smart Electric Panels

August 2025

Energy+Environmental Economics

This whitepaper was prepared by:

Margo Bonner
Christa Heavey
Tianyu Feng
Eric Cutter
Michaela Levine

This whitepaper was funded by:

SPAN.io, Inc

Recommended citation:

M. Bonner, C. Heavey, T. Feng, M. Levine, and E. Cutter, "Unlocking the Value of Smart Panels: The Benefits of a Utility Ownership Model for Electric Smart Panels," Energy and Environmental Economics, Inc., July 2025.

Acronym Definitions

Acronym	Definition
ACC	Avoided Cost Calculator
AMI	Advanced Metering Infrastructure
BE	Building Electrification
CEC	California Energy Commission
CPUC	California Public Utilities Commission
DER	Distributed Energy Resource
DDOR	Distribution Deferral Opportunities Report
DSR	Dynamic Service Rating
EV	Electric Vehicle
GRC	General Rate Case
IEPR	Integrated Energy Policy Report
IOU	Investor-Owned Utility
ISP	Intelligent Service Point
LDV	Light-Duty Vehicle
MW	Megawatt
NEM	Net Energy Metering
NWA	Non-Wires Alternative
O&M	Operations and Maintenance
PAC	Program Administrator Cost Test
PCT	Participant Cost Test
RIM	Ratepayer Impact Measure
SB	Senate Bill
SPM	Standard Practice Manual
TOU	Time-of-Use
T&D	Transmission and Distribution
TRC	Total Resource Cost Test

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Executive Summary

Electric utilities are entering a period of intensifying infrastructure constraints, driven by accelerating load growth associated with building and transportation electrification. The convergence of rising electricity demand, increasingly localized peak loads, and the aging state of distribution assets has exposed critical stress points in the grid. Traditional capital-intensive solutions, such as transformer replacements, feeder reconductoring, and substation expansions, continue to play a role in meeting long-term needs but are often encumbered by extended permitting timelines, high costs, and limited adaptability to dynamic customer demands. In this context, the utility sector is exploring modular, customer-sited technologies that can defer or avoid conventional infrastructure upgrades while maintaining service reliability and enabling equitable access to electrification.

This whitepaper examines the role of smart panels — specifically SPAN® Edge Intelligent Service Point™ (ISP) — as grid assets capable of delivering measurable value to both utilities and customers. SPAN Edge ISP is an advanced service panel supplement installed at the meter that provides circuit-level monitoring and dynamic load control. Its core functionality includes real-time visibility into household electricity usage, software-defined load prioritization, and the ability to reliably and predictably reshape demand in response to grid conditions or pricing signals. The device is designed to be owned and operated by utilities or third-party aggregators and is compatible with standard residential service configurations. Importantly, SPAN Edge ISP enables firm load limiting at the household level, offering a level of precision and reliability in managing peak demand that surpasses typical distributed energy resources. This capability is particularly valuable in addressing last-mile distribution constraints, where clustered electrification from adding EVs and electric space/water heating can quickly overwhelm transformers and service drops. By managing these loads in real-time at the point of interconnection, SPAN Edge ISP can accommodate new load within the existing service limits and mitigate expensive grid upgrades.

To explore the potential benefits of smart panels under a utility ownership model,[1] this whitepaper uses a case study approach to quantify the value of SPAN Edge ISP when deployed to alleviate a localized and specific grid need. Developed by Energy and Environmental Economics (E3), the analysis combines utility grid data, hourly load modeling, and cost-effectiveness metrics used in California's resource valuation frameworks. It is designed to isolate the marginal system benefits attributable to SPAN Edge ISP deployment under varying levels of load growth and device deployment. The analysis is based on a representative residential feeder in California, selected using publicly available hosting capacity data and characterized by emerging electrification loads and limited headroom. While this case study quantifies the value of SPAN Edge ISP on a single representative feeder, the results should not be interpreted as universally indicative of system-wide outcomes. Feeders across a utility's service territory vary in their load growth trajectories and available headroom and thus will demonstrate different cost-benefit profiles. Importantly, SPAN

[1] E3 assumes for the purposes of this analysis, that under a utility ownership model, there are no customer costs for the panel as utility incentives cover the cost.

Edge ISP is particularly well-suited for targeted deployment in areas where these characteristics align with its strengths in deferring grid upgrades and managing flexible residential load.

The methodological approach includes three main components. First, the study models baseline and electrified load profiles for residential customers on the selected feeder, incorporating both electric vehicle (EV) charging and building electrification (BE) end uses. Second, feeder-level simulations assess whether and when the additional load would trigger capacity exceedances that require distribution system upgrades. Finally, the framework quantifies avoided infrastructure costs, bill savings, and other value components using California's Avoided Cost Calculator (ACC) and utility-specific cost data. The results of this analysis are also translated into cost-effectiveness (CE) scores in accordance with the California Public Utilities Commission's (CPUC) CE framework.

Figure 1. Total Net Benefits by SPAN Edge ISP Deployment Level ($NPV/per panel)

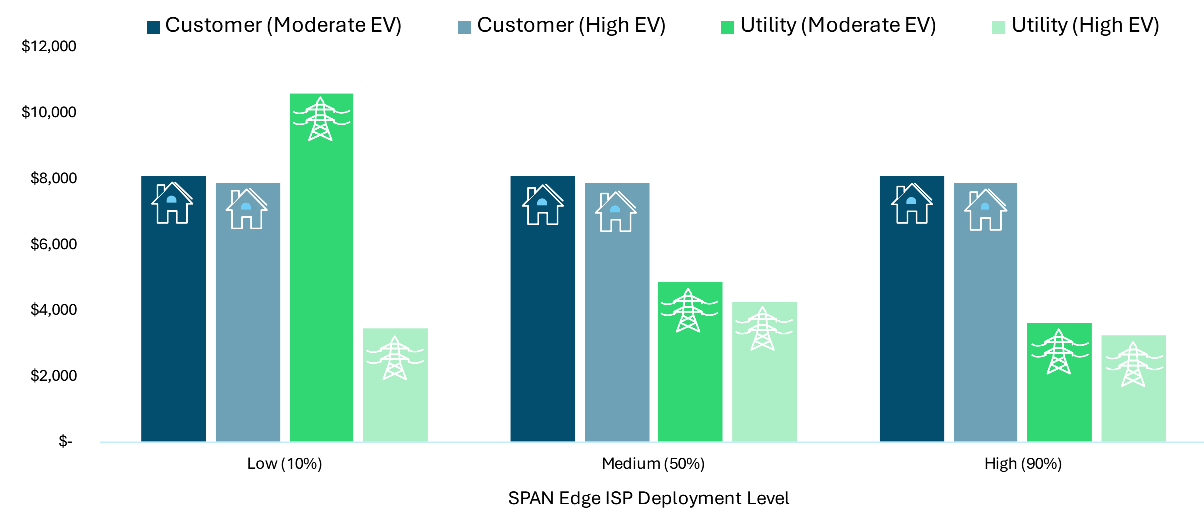
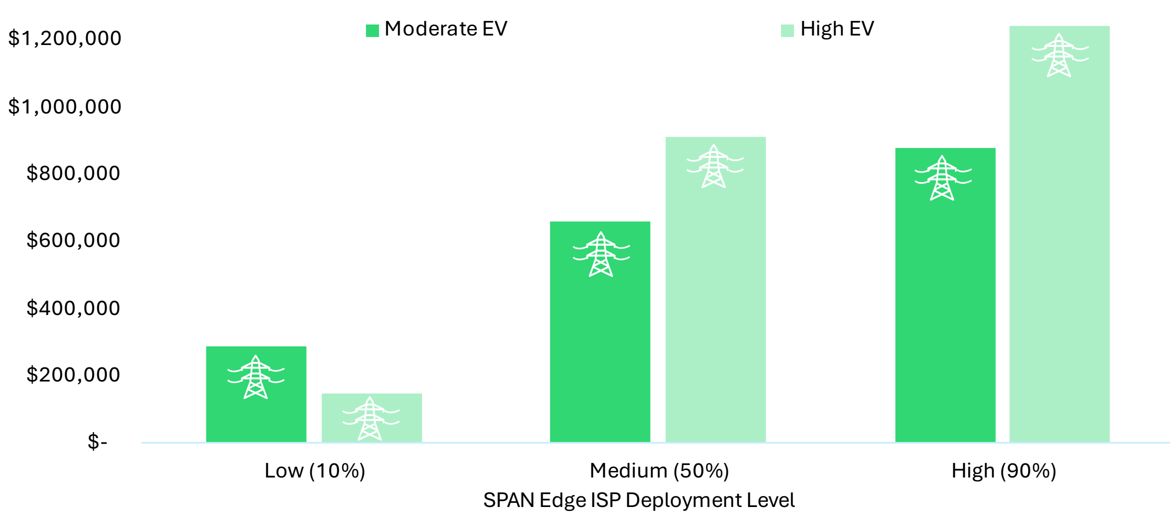


Figure 2. Total Feeder Net Benefits by SPAN Edge ISP Deployment Level ($NPV/per feeder)



Key findings from this analysis are as follows:

- **Customer-level benefits** from SPAN Edge ISP installations are substantial and consistent, averaging **$7,900 to $8,100 per device**. These are primarily driven by avoided panel upgrade and service extension costs, alongside ongoing savings from time-of-use (TOU) load shifting (Figure 1).
- **Utility-level benefits** range from **$3,200 to $10,600 per device** with avoided primary and secondary distribution upgrades and deferred service extension allowances representing the largest sources of value (Figure 1).
- **Total system net benefits (customer + utility)** can exceed **$14,000 per device**, with total resource cost (TRC) test ratios ranging from 3.8 to 6.5 depending on the electrification level and SPAN deployment scale.
- **Utility avoided secondary distribution costs** (in terms of deferred final line transformer upgrades and avoided service extension allowance payments to customers) range from **$101,000 up to $1.16M for the representative feeder** analyzed for this case study**,** driven by SPAN Edge ISP load limiting capabilities.
- **As SPAN Edge ISP deployment increases on a given feeder, total utility benefits increase** (Figure 2), largely driven by bulk system value (avoided energy, capacity, and transmission costs). However, **marginal per-device utility benefits decline due to threshold effects in distribution deferral value.**
- **Pairing SPAN ISP with managed EV charging accounts for the majority of the bulk system and distribution value**, underscoring the importance of load flexibility and behavioral assumptions in capturing system benefits.

E3's analysis confirms that SPAN Edge ISP can offer meaningful and measurable value to both customers and the grid. For individual households, SPAN Edge ISP enables electrification without costly upgrades, while delivering ongoing energy bill savings through dynamic load control. From the utility perspective, SPAN products reliably limit connected load which enables the deferral of traditional infrastructure investments, particularly when deployed in areas with limited grid headroom or accelerating EV adoption.

Critically, the benefits to utilities and ratepayers depend not only on where devices are deployed but also on how many are installed. Distribution system upgrades are typically triggered in discrete capacity increments; therefore, modest deployments that prevent a threshold from being crossed can generate outsized value. Beyond those points, additional devices continue to provide system-level savings but at diminishing marginal benefit. This reinforces the importance of strategic targeting in program design to maximize benefits.

Looking ahead, smart panel deployment offers utilities a practical mechanism to align distribution investment with electrification goals. These devices are well-suited for integration into existing grid modernization programs and provide a transparent, standard-compliant way to manage growing residential loads. For regulators, SPAN Edge ISP represents a technology that aligns with cost-effectiveness metrics, defers rate-based infrastructure, and expands equitable access to electrification.

Introduction

The decarbonization of California's economy is inextricably linked to the electrification of its energy end uses. State legislation, including Senate Bill 100 and Executive Order N-79-20, have established an aggressive trajectory toward zero-carbon electricity and zero-emission vehicle fleets. In parallel, building codes and appliance standards are increasingly directing residential and commercial customers toward electric space and water heating solutions. These transitions, while essential for decarbonization, require a fundamental rethinking of how distribution infrastructure is planned, operated, and upgraded to accommodate new electric load.

Traditional distribution system planning assumes modest, incremental load growth spread evenly across service territories. Capital investments in transformers, service lines, and substations are typically driven by long-term forecasts and executed through multiyear procurement and construction cycles. However, electrification is changing the nature of load growth. Instead of slow and steady increases, utilities are now facing sharp, localized demand surges as clusters of homes install electric vehicle (EV) chargers or replace gas furnaces with electric heat pumps. These surges frequently exceed the design capacity of service drops, secondary transformers, and even feeder lines, thereby necessitating costly and time-consuming upgrades.

In this new landscape, conventional upgrade pathways are increasingly untenable. Transformer replacements can take over a year due to supply chain constraints. Underground service line extensions require expensive trenching and local permitting. In many areas, customers wait months to receive electric service upgrades, delaying the adoption of climate-aligned technologies and frustrating policy timelines.

Moreover, many homes, particularly those built before 2000, are served by electrical panels rated at 100 to 150 amps.[2] These panels cannot accommodate the simultaneous operation of EV chargers, electric heat pumps, induction cooktops, and electric dryers. The default solution of upgrading to a 200-amp panel can cost thousands of dollars, often more when coupled with utility-side upgrades to service drops and transformers. This creates a significant financial and logistical barrier to electrification, especially in lower-income communities and older housing stock. As this paper will demonstrate, smart electric panels offer an alternative solution that can address such barriers.

Load Flexibility and Grid Services from SPAN Edge ISP

SPAN Edge Intelligent Service Point (hereafter referred to as Edge ISP) is a service panel replacement installed at the meter that offers advanced monitoring and control capabilities over household electrical loads. Unlike traditional service panels, SPAN Edge ISP provides continuous circuit-level visibility and the ability to manage connected loads in real time. By integrating metering, sensing, and communication technologies, the device enables coordination between customer electricity use and utility system needs. Designed for utility or third-party ownership, SPAN Edge ISP is compatible with common panel configurations and can be deployed as part of broader utility electrification and grid modernization initiatives.

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[2] https://2023.utilityforum.org/Data/Sites/9/media/presentations/martinez--epri-sce-us-electric-panels.pdf

One of the distinguishing features of SPAN Edge ISP is its ability to reliably limit connected load by enabling household load flexibility. Through disaggregated, circuit-level monitoring and control, the panel can shift or curtail specific end uses, such as EV charging or water heating, to ensure that total concurrent load does not exceed a defined setpoint. This “firm service rating” allows for customers to adopt new electrification technologies without triggering upgrades to their existing electric service. Under the utility ownership model, SPAN also offers a dynamic service rating (DSR), which is a dispatchable service limit that temporarily reduces total connected load below the firm service limit. This DSR can apply at a home level or group of home level for periods of time when there are grid constraints or grid events. When deployed at scale, SPAN Edge ISP-enabled homes can serve as a distributed load management resource that supports distribution capacity planning. By shaping demand at the grid edge, these devices can help defer or avoid infrastructure upgrades, improve load factor, and facilitate customer electrification within existing service limits.

To quantify the value of SPAN Edge ISP load-limiting capabilities under a utility deployment model, SPAN sponsored this white paper and the analysis presented herein. Specifically, this white paper examines the range of benefits that emerge from such capabilities, including the avoided infrastructure value to utilities, accelerated timeline and improved affordability of electrification for customers, and alignment with California’s cost-effectiveness (CE) frameworks for distributed energy resources (DER).

Industry Drivers

California’s decarbonization policy has catalyzed rapid electrification, which in turn is exposing deep limitations in the state’s distribution grid capacity. SPAN technology responds directly to four converging industry pressures: accelerating load growth, widespread panel and service capacity limitations, high-cost and slow-moving utility upgrade cycles, and regulatory friction around grid modernization investment. These forces, which are well documented in current utility filings, grid planning proceedings, and market assessments, point to an urgent need for modular, customer-sited load management solutions.

Electric Load Growth in a Decarbonizing Grid

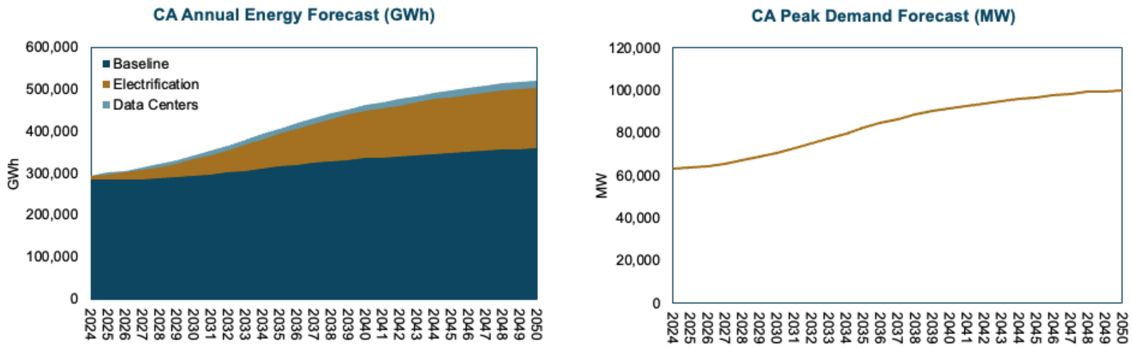
California’s transition to a decarbonized, electrified energy system is producing rapid and transformational electric load growth. This growth presents a dual challenge and opportunity: while it supports climate and economic goals, it also strains an aging distribution system not originally designed for the evolving demands of electrified transport, heating, and digital infrastructure.

E3 modeling, anchored to the California Energy Commission's Integrated Energy Policy Report (IEPR), projects significant statewide increases in electricity demand through 2050 (Figure 3). Under aggressive electrification scenarios aligned with California’s decarbonization mandates, annual load is expected to grow by approximately 12% by 2050, with a faster ramp of 24% through 2035.[3] Such trajectories underscore

[3] E3 Market Price Forecast for CAISO

the need for advanced customer-facing technologies that can align building-level demand with system needs.

Figure 3. California Annual Energy and Peak Demand Forecast through 2050

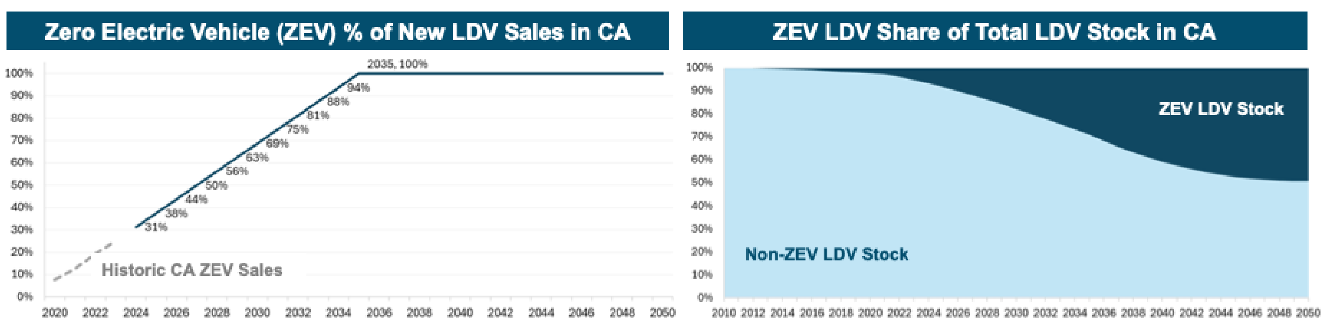


Source: E3 Market Price Forecast for CAISO

There are three main sources of electric load growth:

1. **Load Growth from EVs:** California's transportation sector electrification is advancing under the state's Advanced Clean Cars II regulations, which mandate that all new light-duty vehicle (LDV) sales be zero-emission by 2035. E3 forecasts that by 2035, 13.7 million passenger EVs and 407,000 commercial EVs will be on the road in California (Figure 4).

Figure 4. California EV Sales and Stock Trajectories through 2050



Source: 2022 CARB Scoping Plan LDV Sales and Stock: https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-PATHWAYS-data-E3.xlsx

While EV load can be flexible, unmanaged charging risks exacerbating system peaks, particularly at the secondary distribution level. For instance, a single Level 2 EV charger can draw between 7 to 11 kW[4], equivalent to the peak load of an entire household. If even a modest percentage of homes on a secondary transformer begin charging EVs simultaneously (such as upon returning home in the early evening or at the start of the off-peak period for the local utility rate), the aggregate load can quickly

[4] https://www.pge.com/en/clean-energy/electric-vehicles/getting-started-with-electric-vehicles/electric-vehicle-charging.html#accordion-1b9c719c3f-item-4a21e424e4

exceed the transformer's rated capacity. When this happens, utilities are often forced to initiate upgrades, either replacing the transformer itself, increasing conductor sizing, or upgrading service drops.

2. **Building Electrification (BE) and Policy-Driven Load Growth:** The state's building decarbonization strategy, supported by regional mandates such as the Bay Area's Zero-NOx appliance rules, is accelerating load growth from space and water heating. Beginning in 2026, new residential construction statewide must be all-electric, with similar requirements for commercial buildings by 2029.[5] Existing building retrofits will follow, with full replacement-on-burnout mandates phased in between 2027 and 2030. E3 estimates that electrification of these building loads could add 5,378 MW of new peak demand by 2035.[6]

3. **Data Center and Digital Infrastructure Load:**[7] Driven by surging demand for AI and high-performance computing, data center load is emerging as a new and significant source of electricity demand. Nationwide trends show dramatic increases in data center capacity, and California is not exempt. E3 estimates that by 2050, data centers could account for approximately 3% of total statewide load.[8]

In practice, EV, BE and Data Center load growth will materialize unevenly, increasing pressure on already constrained feeders and transformers in high-growth areas.

Growing Grid Infrastructure Upgrade and Panel Upsize Needs

California's ambitious building electrification and clean energy goals face a significant constraint rooted in legacy electrical infrastructure: inadequate panel capacity across much of the existing housing stock. Electrification of end uses such as space and water heating, vehicle charging, and cooking can drive both panel-level upgrades and utility-side service replacements. Without a coordinated strategy, this transformation risks becoming a major source of cost and delay for utilities, customers, and the grid.

Across the state's ~14 million households, an estimated 50% have electrical panels smaller than 200 amps which is insufficient for fully electrifying a typical home without service enhancements or load management solutions.[9] While some homes with 100–150 amp panels may electrify with careful planning, those below 100 amps (e.g., 40–60 amps) will almost certainly require an upgrade. Events commonly triggering upgrades include EV charger installations, solar PV additions, HVAC replacements, and home renovations such as pool or spa additions.

The complexity and cost of implementing service upgrades vary significantly based on factors such as panel location, distance to the nearest distribution point, the number of customers per transformer, and whether the service is overhead or underground. These upgrades are not limited to the customer panel; they often

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[5] 2025 Building Energy Efficiency Standards: https://www.energy.ca.gov/sites/default/files/2025-07/CEC-400-2025-010-F_0.pdf
[6] Bay Area Air Quality Management District, Grid Impacts of Building Electrification in California: Phase 1 – Final Report, May 2024.
[7] While SPAN products are not directly applicable to data center load growth, the deferral of residential upgrades enabled by SPAN Edge ISP allows utilities to allocate already limited distribution capex towards the interconnection of these high value new loads.
[8] E3 Market Price Forecast for CAISO
[9] SPUR, "Solving the Panel Puzzle," May 2024.

involve utility-side enhancements and, at scale, necessitate upstream distribution system reinforcements. These collective impacts risk cascading into higher system costs and ratepayer burden.

Policy developments are increasingly focused on these grid impacts. The Powering Up Californians Act (SB410) mandates that the California Public Utilities Commission (CPUC) set maximum energization timelines and requires utilities to align annual grid investment planning with regional air quality objectives and to report on missed energization targets.[10] These reforms highlight the growing recognition of the connection between electrification-driven upgrades and equity in grid access.

The implications are profound: service upgrades can cost homeowners anywhere from $2,000 up to $30,000 (without including the cost of the panel upgrade) and take over a year to implement due to permitting, backlog, and utility coordination.[11] At scale, these delays impede decarbonization timelines and increase total system costs.

Long and Expensive T&D Procurement and Planning Process

Electric utilities across the U.S. are rapidly scaling up capital investment in transmission and distribution (T&D) infrastructure. From 2024–2028, more than half of medium-term utility capital spending is expected to be directed toward T&D.[12] Key drivers of this trend include aging asset replacement, wildfire and climate resilience, grid modernization technologies (e.g., smart meters and automated restoration), and the need to accommodate electrification and DERs.

Spending on transmission infrastructure nearly tripled between 2003 and 2023, rising to $27.7 billion, while distribution capital spending rose by $31.4 billion (a 160% increase over the same period). The fiscal consequences of utility grid investments are manifesting in rate cases across the country. In 2023, U.S. electric utilities submitted $13.51 billion in rate increase requests, with a large share tied to T&D capital plans.[13] In California, these trends are directly impacting residential retail rates. Since 2019, PG&E, SCE, and SDG&E have each implemented substantial increases: 87%, 79%, and 41% respectively, equating to 6–11% annualized growth rates.[14] Notably, Southern California Edison (SCE) submitted the nation's largest request, seeking a $3.27 billion increase in California-jurisdictional electric rates over four years (2025–2028), equivalent to nearly $1 billion in new annual revenue.[15]

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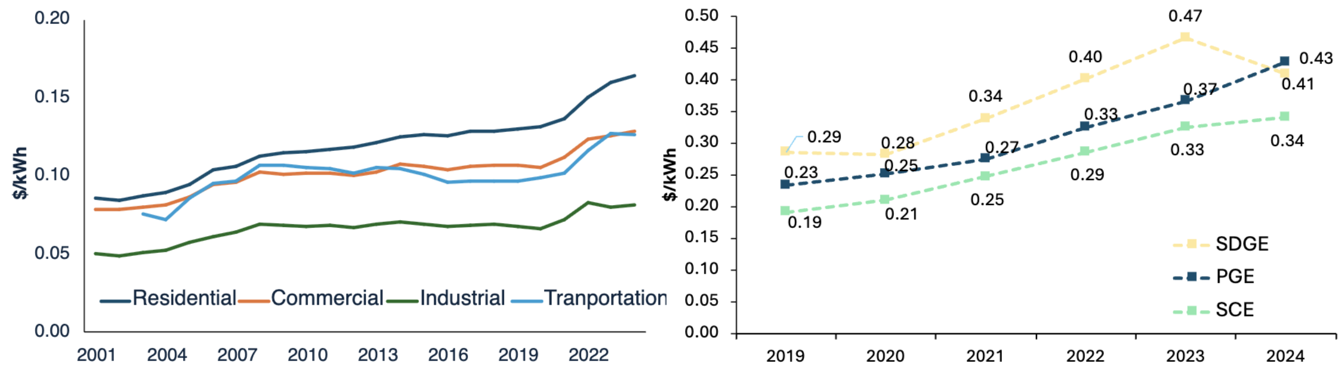
[10] SB410 (2023): https://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=202320240SB410&showamends=false
[11] Rewire America, "Electrification won't break the grid, it will make it smarter."
[12] S&P Market Intelligence, "2023 Annual U.S. Capital Additions by Asset Type"
[13] EIA In-Brief Analysis, "Grid infrastructure investments drive increase in utility spending over last two decades"
[14] E3 analysis, CA State of the Market, April 2025
[15] S&P Market Intelligence, "Rate requests by US energy utilities set record in 2023 for 3rd straight year"

Figure 5. California IOU Residential Retail Rate Increases, 2019–2024



Source: E3 analysis, CA State of the Market, April 2025

Although multiple factors contribute to rising rates (i.e., including wildfire liability, insurance costs, and net energy metering (NEM) shifts), T&D upgrade spending remains a key driver as well. Furthermore, this pressure is not limited to residential customers: commercial, industrial, and transportation classes also face rising rates as grid investment scales.

T&D Procurement and Planning Challenges in California

The process for planning and executing grid upgrades remains lengthy and complex, often misaligned with the urgency of California's electrification goals. In response, the CPUC has mandated new reforms in 2024, requiring utilities to extend the planning horizon of their Distribution Planning Process (DPP), introduce a "pending loads" category, and assess load flexibility within their DPP filings. Still, infrastructure deployment remains slow. PG&E, for example, reports typical residential service upgrades take 10–30 days, but may extend beyond 8 months for more complex cases (Table 1). New construction connections average 64 days. More significant distribution projects, such as substations and new circuits, often require 3–10 years from initiation to in-service.[16]

Table 1. California IOUs Distribution Planning and Execution Process

IOU	PG&E		SCE		SDG&E	
Project Type	Upgrade Time	Planning Horizon	Upgrade Time	Planning Horizon	Upgrade Time	Planning Horizon
Distribution line work	1-3 years	3 years	1.5-2 years	5 years	1 year	3 years
Adding a new circuit from an existing substation	2-3 years	5 years	2-3 years	5 years		5 years
Add or replace substation transformer at existing substation	3-4 years	5+ years		10 years		5+ years
Build a new substation	5-7 years	5+ years	7-10 years	10 years		5+ years

Source: CPUC 2024 Staff Proposal for the High DER Proceeding, timelines not published for all project types for SCE and SDG&E

[16] CPUC, "2024 Staff Proposal for the High DER Proceeding," April 2024; BAAQMD, "Grid Reliability and Interconnection Challenges," September 2024

These delays are rooted in procurement lead times, permitting, workforce constraints, and system coordination and can create bottlenecks for customers and developers alike. Long timelines also raise the total cost of deployment and risk deferring load growth needed to achieve state electrification targets.

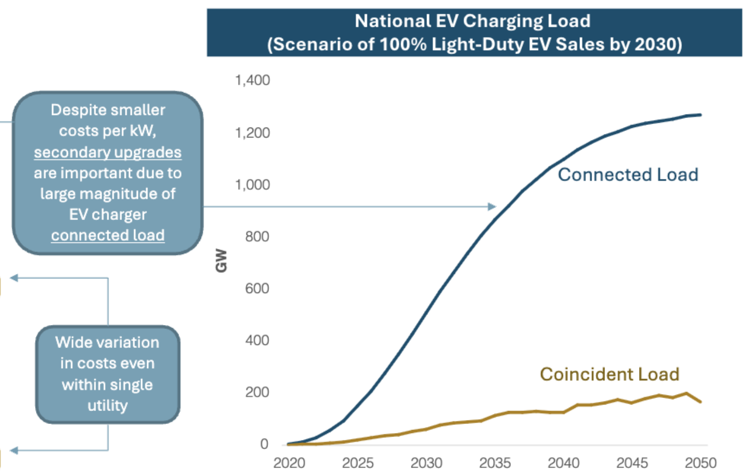
Rising Costs in the Secondary Distribution System

While primary distribution upgrades typically receive planning focus, electrification is placing increasing stress on secondary systems, especially for residential and small commercial loads served at the last mile. According to PG&E's general rate case data, secondary distribution costs are smaller per kW than primary costs (ranging from ~$0.88 to $1.75/kW-year), yet their cumulative magnitude is substantial due to the growing base of EV charger connected loads (Figure 6).[17]

Figure 6. PG&E Distribution Costs and National EV Charging Load Forecast

Example Costs: PG&E GRC Data used for 2020 Avoided Cost Calculator

PG&E Distribution Planning Area	Primary $/kW-yr	Secondary $/kW-yr	Secondary/ Primary Cost
Central Coast	$69.09	$1.04	2%
De Anza	$35.65	$1.01	3%
Diablo	$17.78	$1.56	9%
East Bay	$19.99	$0.88	4%
Fresno	$39.52	$1.36	3%
Humboldt	$73.97	$1.12	2%
Kern	$34.07	$1.23	4%
Los Padres	$56.49	$1.06	2%
Mission	$13.63	$0.97	7%
North Bay	$29.42	$1.75	6%
North Valley	$53.40	$1.26	2%
Peninsula	$31.79	$1.06	3%
Sacramento	$40.91	$1.22	3%
San Francisco	$40.41	$1.52	4%
San Jose	$40.12	$1.16	3%
Sierra	$30.65	$1.25	4%
Sonoma	$121.98	$1.28	1%
Stockton	$33.36	$1.34	4%
Yosemite	$60.18	$1.56	3%



In planning areas like Mission and Diablo, secondary costs comprise up to 9% of primary infrastructure costs. As light-duty EV adoption expands under California's 2035 ZEV mandate, these downstream systems will require significant reinforcement, even when upstream capacity is sufficient. A 2023 study by E3 and GridLab highlights how secondary upgrades, though often unrecognized in traditional planning, could drive large cumulative costs due to high connected loads relative to coincident peak (if not well-managed). This underscores the need for technologies that can manage localized load impacts without full infrastructure replacement.

Grid Modernization Regulatory Challenges

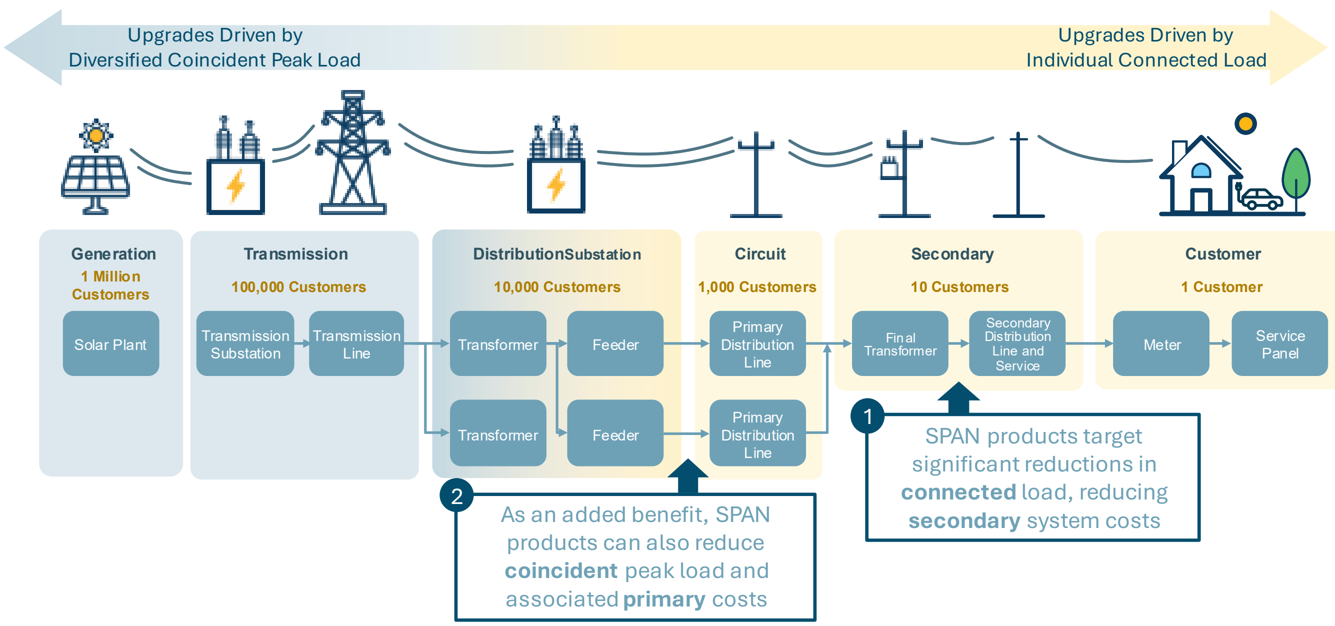
Despite widespread recognition of the need for grid modernization, utility efforts to secure ratepayer funding for advanced infrastructure upgrades often falter under regulatory scrutiny. In 2021, utilities across the U.S. filed for $14.7 billion in grid modernization investments. Of this, regulators approved just $904 million, deferring $12.7 billion subject to further review and rejecting the remainder.[18] Many proposals stalled due to

[17] E3 and GridLab analysis, Distribution Cost Impacts Driven by Transportation Electrification
[18] Utility Dive. "Duke, SCE and other grid modernization proposals confronted big cost questions in 2021."

high capital costs, lack of clearly defined benefits, or uncertainty about technology maturity. The lengthy and adversarial nature of regulatory review often deters utilities from pursuing innovative or nontraditional solutions. This dynamic has created an opening for lower-cost, modular technologies that can be deployed incrementally and evaluated on performance.

In summary, California's electric utilities face converging challenges of rapid electrification-driven load growth, widespread panel and service capacity constraints, costly and protracted grid upgrade processes, and regulatory pressure to modernize distribution infrastructure while maintaining customer affordability. Smart panels, particularly when deployed under a utility ownership model, can serve as a flexible, cost-effective tool to mitigate these challenges. As illustrated in Figure 7, SPAN Edge ISP functions as a form of utility infrastructure that reduces both individual connected load and diversified coincident peak load, delivering value across the secondary and primary distribution systems. By dynamically managing household energy use and reliably limiting connected load, SPAN Edge ISP enables customers to electrify without triggering costly panel or service upgrades and allows utilities to defer or avoid infrastructure investments across both the primary and secondary distribution system.

Figure 7. The Role of SPAN Edge ISP as Utility Distribution Infrastructure



Methodology

Benefit Valuation Framework

To quantify the grid and customer value of SPAN Edge ISP, E3 developed a benefit value stack analysis applied to a representative summer-peaking feeder selected from a California IOU's public grid hosting capacity database. The selected feeder represents conditions typical of residential neighborhoods with emerging electrification loads, including new construction activity and moderate rooftop solar adoption. E3 estimated benefits from deploying SPAN Edge ISP devices under varying levels of household electrification and SPAN device deployment, incorporating hourly load shapes for EVs and BE, adjusted to reflect the impacts of SPAN's load management capabilities. Where applicable, E3 categorized and quantified benefits using established avoided cost frameworks and developed additional calculations to capture distribution and customer-level values not typically included in standard cost-effectiveness tools.

Feeder Selection and Baseline Characterization

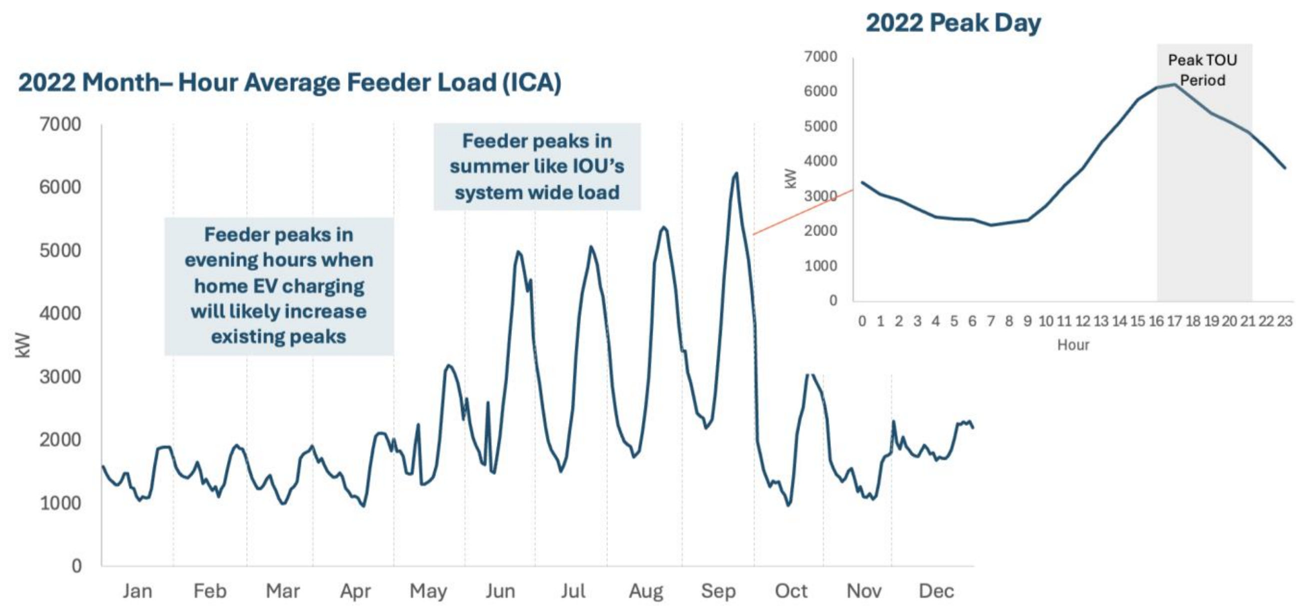
E3 leveraged publicly available IOU hosting capacity databases to identify a representative distribution feeder with primarily residential customers, constrained headroom, and electrification potential. The feeder includes 502 single-family homes and operates on a 12 kV underground system with an existing peak load of 6.2 MW and ~0.5 MW of headroom. Figure 8 illustrates the geographic layout of the selected distribution feeder in Southern California. This territory includes both established neighborhoods and newly constructed housing developments, with underground electrical distribution circuit shown as line segments in the image below.

Figure 8. Satellite Imagery of Selected Feeder

Source: [IOU ICA Database]()

As summarized in Figure 9, the selected feeder's load profile displays summer peak behavior and high evening loads, the timing of which aligns with EV charging and BE demand. These characteristics make the selected feeder a high-value candidate for deferral of capital investment through targeted DER deployment.

Figure 9. Representative Feeder Load Profile



Source: [CA IOU ICA Database]

BE and EV Load Forecasting with and without SPAN Edge ISP

After feeder selection, E3 assessed how SPAN technology could reshape load profiles and reduce the need for distribution system upgrades under realistic scenarios of adoption and demand growth. This involved constructing EV and BE load shapes, both with and without the influence of SPAN Edge ISP. These shapes were designed to reflect realistic charging behavior and appliance usage patterns, as well as SPAN technical capabilities to shift or throttle load to avoid peak periods.

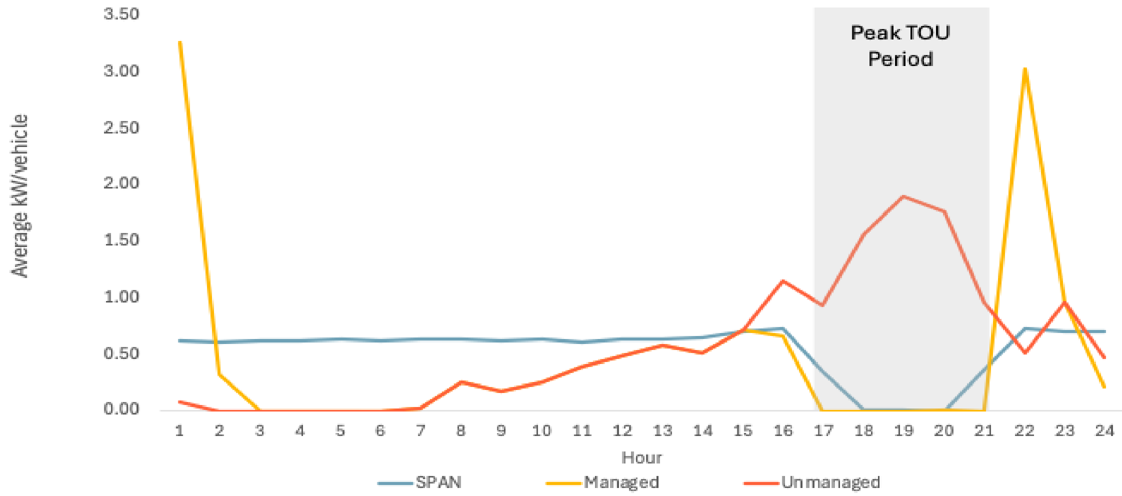
EV Load Shapes

E3 leveraged its EVGrid model, a bottom-up simulation tool that estimates EV charging needs based on vehicle characteristics and real-world travel behavior, to develop EV charging profiles. The model calculates where, when, and how much charging is required for a diverse population of vehicles. Multiple scenarios of driver behavior were simulated (Figure 10):

+ **Unmanaged charging** assumes drivers begin charging immediately upon returning home, typically during on-peak periods.
+ **Managed charging** assumes drivers defer charging until the start of off-peak pricing windows, often resulting in rebound peaks.
+ **SPAN-managed charging** models a scenario in which charging is distributed across off-peak hours with minimal power draw, subject to meeting all travel demands. This represents a theoretical maximum load minimization potential enabled by SPAN real-time control capabilities.

In the absence of SPAN Edge ISP, E3 assumes a behavioral mix of 60% TOU-managed and 40% unmanaged charging. With SPAN Edge ISP, 100% of the modeled vehicles are assumed to follow SPAN-optimized charging schedules.

***Figure 10. Population average home charging load of 200 vehicles on a summer day*[19]**



Source: E3 EVGrid tool

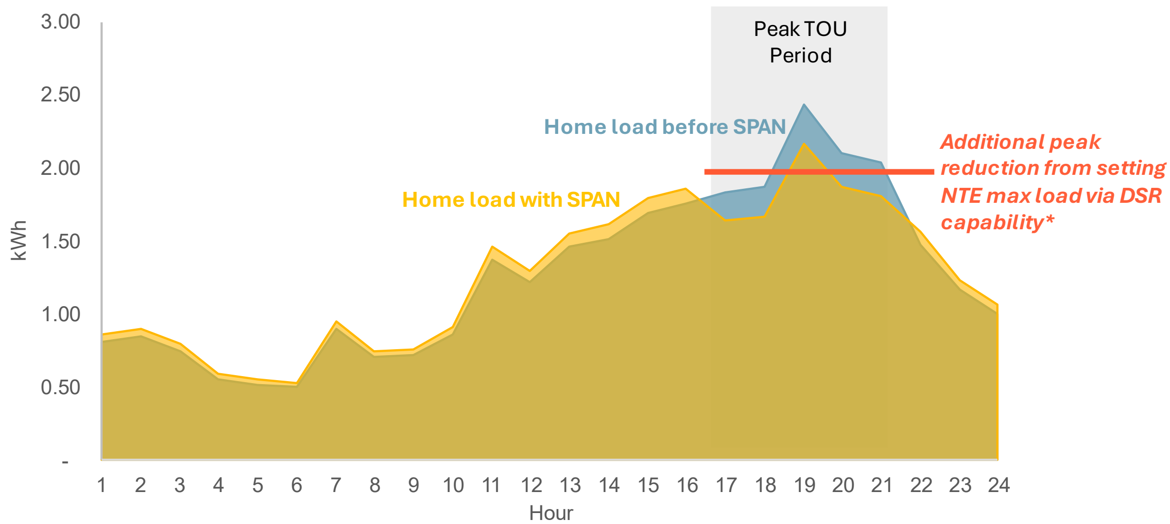
BE Load Shapes

E3 leveraged household-level energy use data from the National Renewable Energy Laboratory's (NREL) ResStock database to construct building load profiles for the homes in the selected feeder. For each sampled home in the selected study area (Los Angeles County), E3 created pre- and post-electrification hourly load profiles.[20] Impact from SPAN on BE was modeled as a shift of 11% of flexible end-use load (e.g., water heating, HVAC) from peak and mid-peak hours to off-peak periods (Figure 11). SPAN Fleet Energy Management dataset, which quantifies load flexibility during two-hour event windows for different appliance types, informed this load shift percentage.

[19] Figure shows population average charging behavior under the three scenarios and does not indicate a single vehicle's behavior. For example, the SPAN-optimized charging scenario does not represent all vehicles being at home and charging all day except for the peak-period. Rather, this represents the population average where different vehicles have different travel needs, and on average this distributes charging load throughout the day.

[20] Building characteristics: 2,500 ft^2, detached single-family house with central cooling, built in 2010s

Figure 11. Summer Day Single House BE Load Shifting with SPAN



Source: ResStock; SPAN assumptions. *DSR capability not modeled as part of this analysis. Graphic depiction is for illustrative purposes only.

While SPAN Edge ISP can also enforce a Dynamic Service Rating (DSR) over a group of homes, E3 did not explicitly model this constraint in the hourly simulation since DSR operates primarily at a sub-hourly level and would not meaningfully change net hourly demand. The analysis therefore represents a more conservative approach where customers experience minimal to no noticeable impact on an hourly basis. DSR functionality could increase net benefits shown in the analysis by enforcing a lower service limit on peak days.

Feeder-Level Load Modeling

E3 applied the incremental electrification loads, derived from both EV and BE modeling to the representative feeder, adding varying levels of load from projected heat pump and EV adoption to the historical baseline feeder load:[21]

- **Moderate EV and heat pump** uptake assumes 54% EV adoption and 27% penetration for heat pumps
- **Accelerated EV uptake** assumes 2035 projected penetration of EVs (85%); heat pump penetration held at moderate levels (27%)

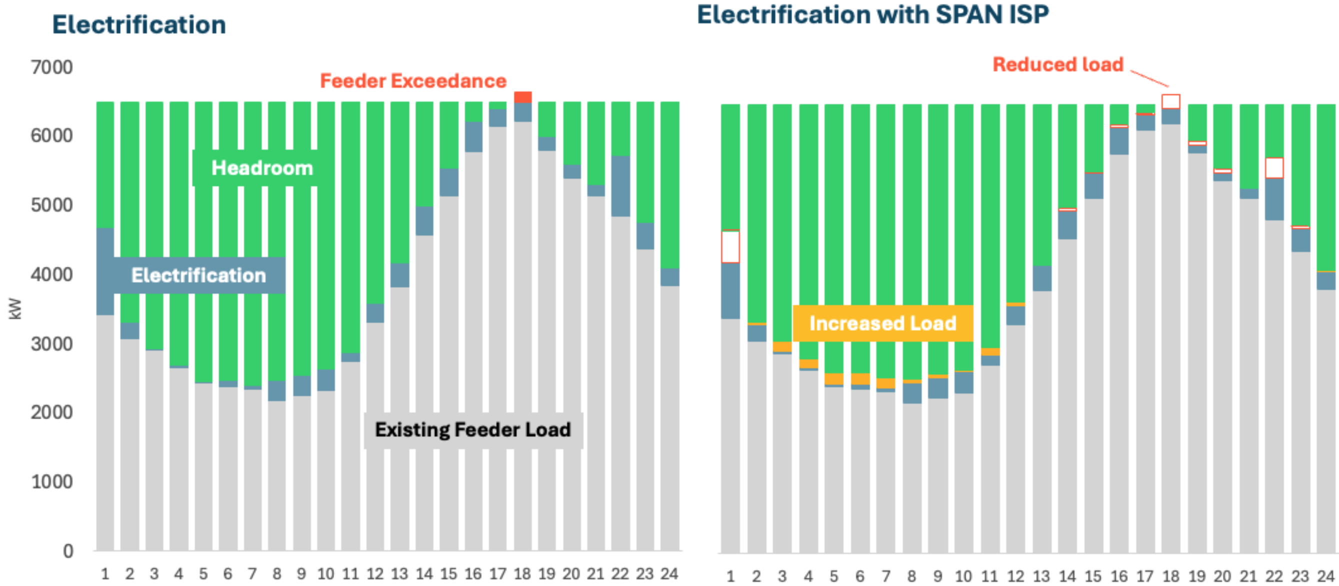
E3 then adjusted these load profiles under varying levels of SPAN Edge ISP deployment: low (10%), medium (50%), and high (90%) adoption across electrifying customers.[22] The aim was to evaluate how SPAN Edge ISP could shift load from peak periods and mitigate infrastructure upgrade needs at various levels of technology saturation. This modeling provided the foundation for estimating avoided utility capital costs, customer upgrade savings, and demand-side flexibility value associated with SPAN deployment.

[21] HP and EV adoption levels come from the California Energy Commission's [2023 Integrated Energy Policy Report]
[22] For this analysis, deployment percentages translated to 28, 136 and 244 units for low, mid and high assumptions, respectively

Distribution Upgrade Avoidance and Threshold Effects

Feeder upgrade triggers are modeled as capacity exceedances (Figure 12). Where electrification causes hourly load to exceed feeder limits, E3 assumes a distribution upgrade (minimum 0.5 MW increment) is required and credits primary distribution deferral benefits when SPAN Edge ISP load shaping successfully mitigates the overload.

Figure 12. Feeder-level 2022 Baseline and Electrified Load with and without SPAN



Source: E3 analysis and IOU hosting capacity database

It is important to note that the threshold nature of distribution upgrades creates a non-linear relationship between SPAN Edge ISP adoption and benefits: penetration up to a certain point can avoid a full upgrade and yield high per-unit benefits, while partial deployment in high-load scenarios may fall short and provide no deferral value at all. Similar to energy-limited storage, the marginal capacity of SPAN Edge ISP value decreases with scale.

Benefit Analysis by Value Stack Component

After developing load shapes with and without SPAN Edge ISP and determining feeder upgrade triggers, E3 calculated costs and benefits for each of the following components of the valuation framework:

+ **Energy, Generation Capacity, and Transmission Capacity:** System-level savings were quantified using hourly prices from the 2024 California Avoided Cost Calculator (ACC), applied to the shifted load enabled by SPAN Edge ISP. For customer-level calculations, avoided energy costs reflect utility bill savings by shifting energy use from peak and mid-peak to off-peak hours in response to

TOU rate. Generation capacity benefits are derived from customer incentives from participation in demand response (Critical Peak Pricing) programs.[23]

+ **Primary Distribution:** Distribution deferral value is based on the projected peak reduction from SPAN deployment and the avoided cost of capacity upgrades at the feeder level. To localize benefits, E3 reverses the ACC's regional averaging of distribution costs by reapplying upstream input parameters from SCE's DDOR. Specifically, per-unit avoided upgrade costs ($/kW) are combined with SCE's marginal cost factor (11.48%) and O&M savings to produce a feeder-specific deferred value of $197/kW-year.
+ **Secondary Distribution:** Transformer and final line cost estimates use typical upgrade costs for pad-mounted transformers serving small groups of homes, attributing savings where SPAN Edge ISP deployment deferred or reduced the need for these upgrades.[24]
+ **Service Extension and Customer Panel:** The analysis included avoided utility allowances for service extensions (CPUC Electric Tariff Rule 15) and avoided customer costs for panel upsizing. E3 assumes that in the counterfactual, 20% of electrifying homes would otherwise trigger a costly service extension, with an average cost of $8,000 plus the utility service extension allowance. It is important to note that benefits to both the utility and the customer can vary significantly depending on whether the standard panel upsize would have triggered a service extension upgrade, and the cost of this extension beyond the utility's standard allowance. The 20% assumption used for this analysis will likely be much higher if initial deployments of SPAN ISP Edge are targeted to high-growth high-congestion feeders. The standard panel upgrade cost assumption is $3,000 per home, based on statewide averages.[25] SPAN Edge ISP panel costs are based on the cost of the panel and monthly service fees.[26]

Cost-Effectiveness Calculations

To evaluate SPAN Edge ISP deployment within the framework used by California's IOUs and regulators, E3 translated the quantified benefits and costs from the feeder analysis into standard DER cost-effectiveness metrics using the California Standard Practice Manual (SPM) methodology. These cost-effectiveness (CE) tests are used by the CPUC to assess whether utility programs deliver net benefits from different stakeholder

[23] E3 assumed $20 per household per year based on average annual savings for participation in SCE's Power Saver Rewards Program. SPAN ISP Edge could enable homeowners to enroll in additional DR offerings that yield higher annual incentives, which would increase the range of potential customer benefits from SPAN Edge ISP.

[24] E3 assumes a per-unit FLT upgrade cost of $11,290 (including transformer and service drop), based on SCE's 2024 Unit Cost Guide. Diversity factors are applied to adjust for realistic coincidence of household loads

[25] Source: https://homes.rewiringamerica.org/articles/electrical-panel/electrical-panel-upgrade-pros-cons. Note: Installation costs from certified electrician included in standard panel cost estimate. Since SPAN ISP does not require electrician installation, SPAN Edge ISP device costs are limited to panel cost and software fee.

[26] SPAN Edge ISP costs as follows: $1,500 upfront cost of SPAN Edge ISP + annual service cost of $120/year * 10 years

perspectives. E3 applied the value components from the benefit stack to three major tests: TRC, PAC, and PCT.[27]

- The **Total Resource Cost (TRC)** test evaluates whether the total benefits to all participants and the utility system exceed the total costs, regardless of who pays for them. It includes avoided energy, capacity, transmission, and distribution system costs as benefits. Costs include both customer and utility-borne expenses, such as equipment and installation.
- The **Program Administrator Cost** (**PAC)** test measures cost-effectiveness from the utility or program administrator perspective. It includes the same avoided utility system costs as the TRC but counts only the costs incurred by the utility to implement the program. This makes the PAC particularly relevant for regulatory approval of utility investment or pilot program proposals.
- The **Participant Cost Test (PCT)** evaluates the cost-effectiveness of a program from the customer's perspective. It considers bill savings, avoided capital costs (such as panel or service upgrades), and available incentives as benefits, and includes any customer payments for equipment or services as costs. When applied to SPAN Edge ISP, PCT benefits included avoided panel upgrade costs, avoided service extension costs beyond the utility allowance, and ongoing energy bill savings from TOU load shifting.

These tests were calculated for each combination of SPAN Edge ISP deployment and electrification load growth analyzed under the benefit valuation framework where SPAN Edge ISP deployment successfully deferred a primary distribution system upgrade. Table 2 below summarizes how the benefit valuation framework categories were treated for each cost test.

Table 2. CE Mapping Summary

Component	TRC	PAC	PCT
Avoided Energy Cost	Benefit	Benefit	NA
Avoided Capacity Cost	Benefit	Benefit	NA
Avoided Transmission Cost	Benefit	Benefit	NA
Utility Bill Savings (Energy + Capacity)	NA	Cost	Benefit
Avoided Primary Distribution Cost	Benefit	Benefit	NA
Avoided Secondary Distribution Cost	Benefit	Benefit	NA
Panel and Service Cost (Program Cost)	Cost	Cost	Cost*
Avoided Service Extension Allowance	Benefit	Benefit	NA
Avoided Panel Cost	Benefit	NA	Benefit
Avoided Service Extension Cost	Benefit	NA	Benefit
Admin Cost (10%* Program Cost)	Cost	Cost	NA

*Reflects customer's portion of panel cost for scenario where cost was split among utility and customer. For all other scenarios that assume utility deployment, participant costs were zero

[27] The Ratepayer Impact Measure (RIM) test was not included in this analysis, as its focus on utility revenue impacts from reduced electric throughput is less relevant for a program aimed at avoiding discrete capital investments rather than reducing volumetric energy costs. Instead, this whitepaper emphasizes the PAC test, which offers a more meaningful assessment of overall cost-effectiveness and impact on ratepayers by appropriately capturing the avoided infrastructure expenditures (e.g., panel upgrades, service extensions, and distribution system reinforcements) that the load flexibility of SPAN Edge ISP enables.

Results

The results presented in this section quantify the utility and customer benefits of SPAN Edge ISP when deployed as a distribution-side resource, demonstrating how targeted deployment of SPAN Edge ISP panels can (1) provide measurable distribution deferral value to utilities, (2) enable customers to more affordably electrify, and (3) generate cost-effective outcomes that can be evaluated using the CPUC's CE protocols.

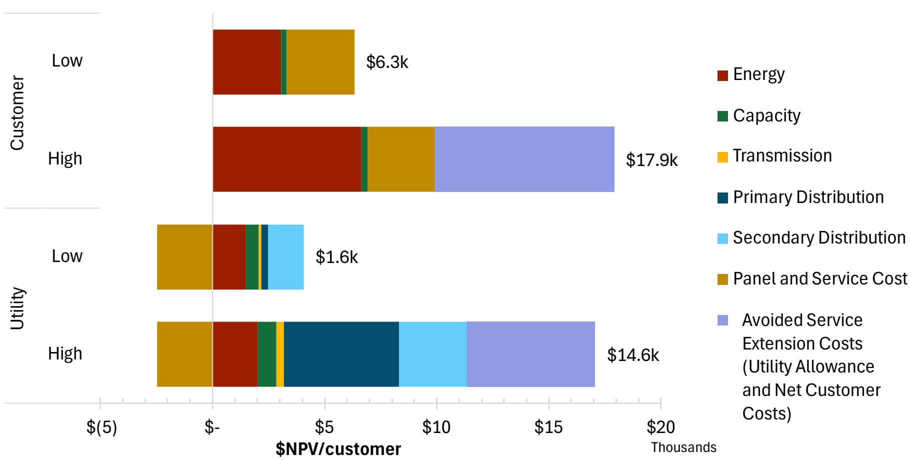
Benefit Analysis Results

Upper and Lower Bound Estimates

The range of potential benefits associated with utility deployment of SPAN Edge ISP varies significantly depending on several key assumptions, most notably, the presence of managed EV charging in the counterfactual and whether standard panel upgrades would have triggered costly service extension work. These factors directly influence both the utility's avoided infrastructure costs and the customer's out-of-pocket savings.

At the high end of the benefit range, assuming low levels of managed EV charging prior to SPAN deployment and the presence of costly service extension upgrades, the total NPV of benefits can reach approximately $14,600 per panel for the utility and $17,900 per panel for the customer. These high-value scenarios are characterized by the combination of substantial avoided panel and service upgrade costs, enhanced energy savings from peak load shifting, and deferred investment in distribution infrastructure. Conversely, if moderate levels of managed charging are already occurring without SPAN, and customers would not have required a service drop even in the absence of SPAN, the resulting benefits are considerably lower. Under these conditions, the utility net benefit declines to approximately $1,600 per panel, and the customer benefit to $6,300 per panel (Figure 13).

Figure 13. Summary of High and Low Estimates of Potential Benefits ($/customer)



These high and low-end estimates highlight the sensitivity of the value proposition of SPAN to local grid conditions and baseline customer behavior. For utilities, the most significant drivers of value are avoided distribution upgrades and deferred service extension allowances. For customers, the avoided cost of panel upsizing and service connection work, combined with load shifting savings under TOU rates, represent the largest sources of benefit. As such, SPAN Edge ISP deployment may be most impactful when targeted in areas with high electrification potential, limited grid headroom, and minimal existing load management.

Results from Benefits Analysis based on Representative Feeder

The following section summarizes the results for the cost-benefit analysis based on a representative feeder. It is based upon the assumptions described in Methodology, Benefit Analysis by Value Stack Component and does not rely upon the same assumptions used in the bookend scenarios described above.

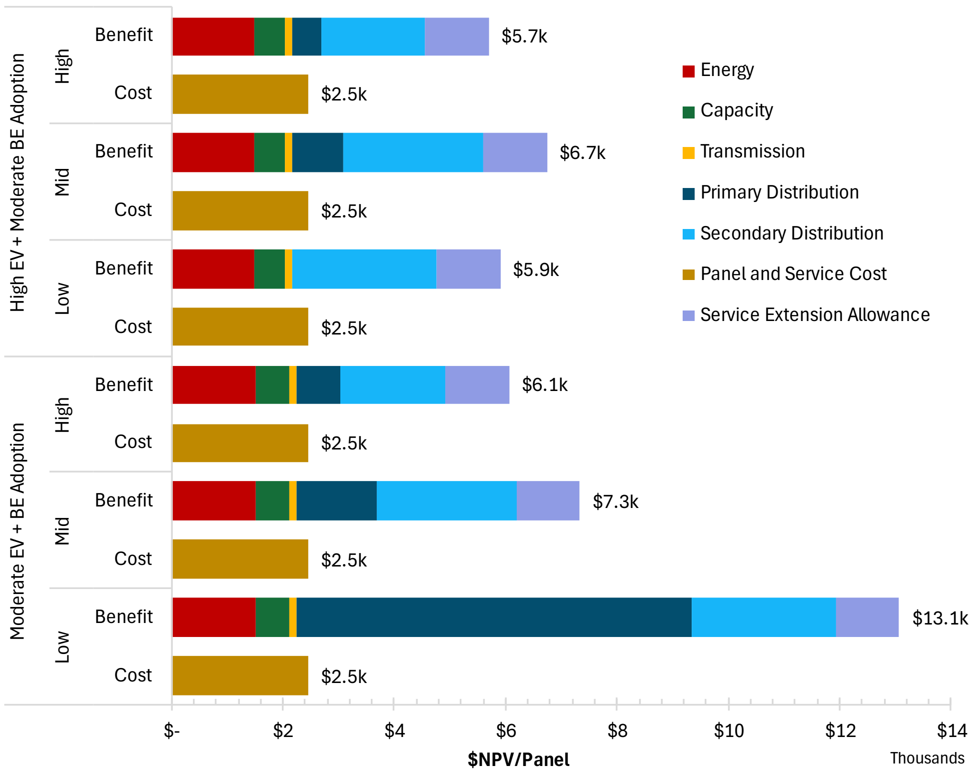
Customer Benefits

Customer benefits per panel are consistent across SPAN deployment levels and only slightly increase between moderate and more aggressive EV adoption trajectories, ranging from approximately $7,900 to $8,100 per panel, respectively. This is because avoided service extension, avoided panel cost, and capacity benefits are consistent at the customer level regardless of electrification levels. Energy benefits only vary slightly as they are primarily driven by enhanced EV management and higher participation rates in managed charging. Notably, these benefits remain stable across SPAN adoption levels, underscoring that individual customers realize high value regardless of overall system penetration.

Utility Benefits: Panel-level

Figure 14 summarizes per-panel benefits from the utility perspective, demonstrating that varying levels of electrification can yield meaningful variation in utility benefits depending on the level of SPAN Edge ISP penetration and corresponding avoided infrastructure costs. With moderate EV and BE adoption, per-panel utility benefits range from approximately $10,600 at low SPAN Edge ISP adoption to $3,600 at high adoption levels. This decline in per-panel value as penetration increases reflects the threshold nature of distribution upgrades: a small number of panels (in this case, 28 units) can avoid a costly infrastructure investment, but the marginal benefit of each additional panel diminishes as system needs are already met. Across all Edge ISP deployment levels, bulk system benefits (energy, capacity, transmission) remain consistent, largely driven by the ability of SPAN panels to manage EV charging loads.

Figure 14. Utility Benefits: $/Panel



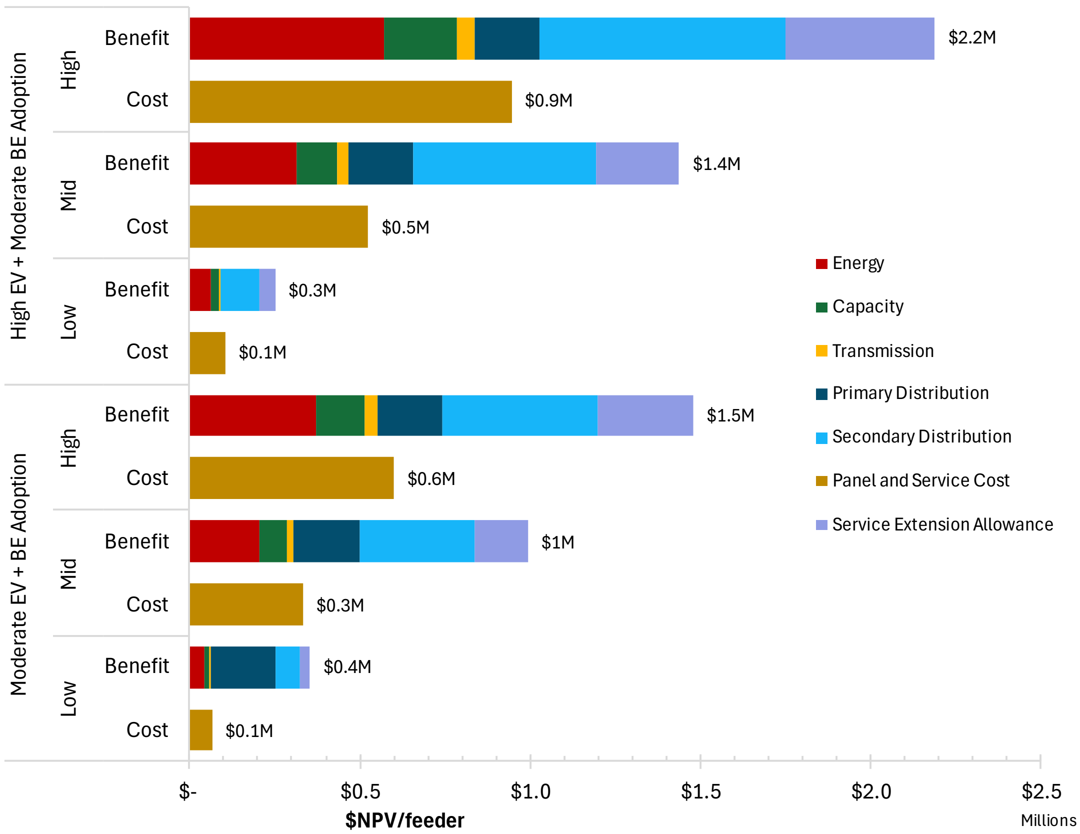
Note: Low, Mid and High refer to the level of SPAN Edge ISP deployment: low (10%), mid (50%), and high (90%)

Under higher EV adoption with moderate heat pump penetration the pattern is similar. Per-panel utility benefits range from $3,400 at low adoption to $3,200 at high adoption. Importantly, primary distribution benefits are not captured at low SPAN Edge ISP adoption, reaffirming the requirement for critical mass to unlock feeder-level upgrade deferrals. Taken together, these results demonstrate that targeted, moderate deployment levels yield the highest cost-effectiveness per dollar invested, while high saturation primarily amplifies bulk system benefits rather than distribution savings.

Utility Benefits: Feeder-level

Feeder-level utility benefits from SPAN Edge ISP deployment vary significantly by both electrification intensity and SPAN penetration levels, reflecting the interplay between localized grid constraints and the threshold-based nature of distribution upgrades. As summarized in Figure 15, feeder-level total net benefits can reach up to $0.9 million under moderate EV and BE adoption and $1.2 million per feeder under high EV adoption at full SPAN saturation. Under high EV and moderate BE adoption, primary distribution upgrade deferral is captured at mid and high SPAN deployment levels, holding constant across those cases since the same feeder upgrade is avoided. Secondary distribution benefits, by contrast, scale with adoption: higher SPAN Edge ISP penetration enables greater deferral of transformer and service line upgrades, increasing total net benefits per feeder. Bulk system benefits (i.e., energy, capacity, and transmission) also rise with SPAN Edge ISP saturation, driven by the device's ability to reshape EV load profiles in ways that reduce coincident peaks.

Figure 15. Utility Benefits - $/Feeder



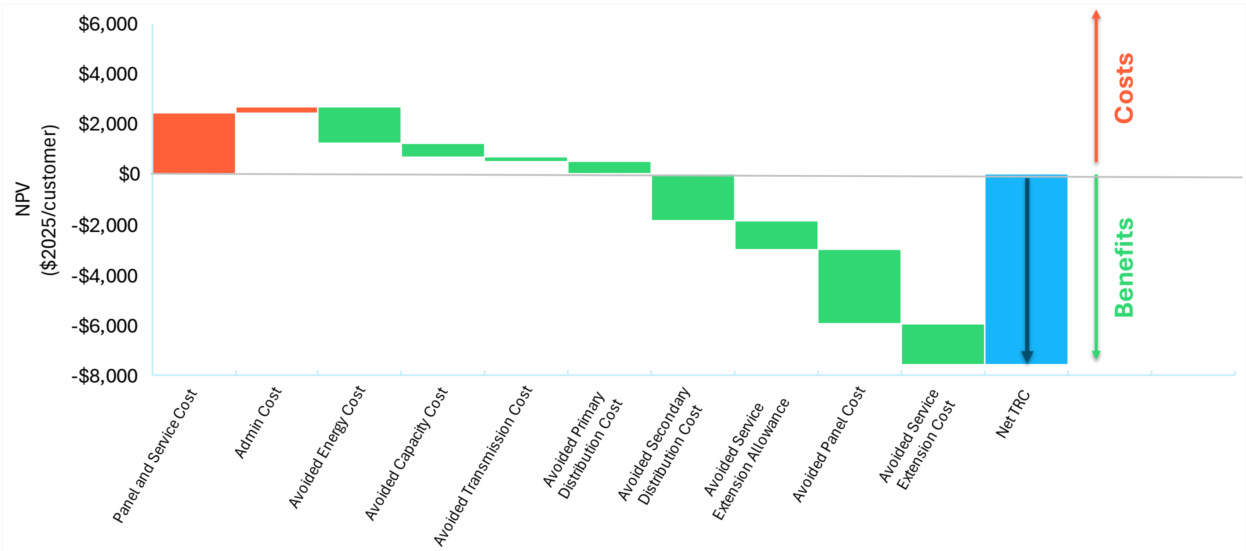
Note: Low, Mid and High refer to the level of SPAN Edge ISP deployment: low (10%), mid (50%), and high (90%)

CA Cost-Effectiveness Results

The cost-effectiveness analysis confirms that SPAN Edge ISP delivers strong net benefits across multiple stakeholder perspectives when deployed in support of residential electrification. Under moderate electrification with mid-level SPAN adoption (50%), the TRC test yields a benefit-cost ratio of 4.41, with net benefits of $9,228 per panel, driven by avoided distribution system upgrades, panel and service extension cost deferrals, and modest energy and capacity savings. From the participant perspective, the PCT test indicates $8,093 in lifetime net benefits per household, reflecting the savings from customer-borne panel upgrade costs and service extension charges, alongside bill reductions from managed EV charging. Although the PAC test is more conservative, it still produces positive net benefits, affirming cost-effectiveness from the utility's perspective even when the customer does not pay for some or all of the electric panel.

High SPAN deployment (90%) with aggressive EV adoption also demonstrates cost-effectiveness, although not as high as the scenario described above. Here, the TRC test shows net benefits of $7,592 per panel, with a benefit-cost ratio of 3.81, while customer-level benefits remain high at $7,917 (see Figure 16). These gains are primarily attributable to the substantial avoided costs associated with bulk energy and capacity procurement, as well as deferral of localized distribution upgrades. Although the PAC test result for this scenario is slightly negative (–$325 per panel), this outcome reflects the flattening marginal value of distribution deferral as deployment saturates, emphasizing the importance of targeting SPAN deployment in areas with clear grid upgrade triggers. For a full summary of CE test results and calculations, see Appendix A. Detailed CE Results.

Figure 16. High EV Adoption + High SPAN Edge ISP Deployment: Average Lifecycle Costs per/Customer



Overall, these findings demonstrate that SPAN Edge ISP can be deployed cost-effectively at both moderate and high penetration levels, particularly when aligned with areas of high electrification potential and constrained grid capacity.

Qualitative Benefits

In addition to the monetized values captured through E3's benefit-cost framework, smart electrical panels like SPAN Edge ISP can enable a range of qualitative benefits relevant to both utilities and customers. From a utility planning and operations perspective, these devices offer a potential mechanism to reduce barriers to electrification by allowing customers to connect new electric loads (e.g., electric vehicles, heat pumps) without requiring panel or service upgrades. This capability can accelerate load growth in a manner that increases electricity sales while minimizing strain on distribution infrastructure. By managing demand at the circuit level, smart panels can also simplify the regulatory and engineering processes associated with distribution system upgrades, offering an incremental and flexible alternative to traditional investments. In high-need areas, this may support non-wires alternatives and defer capital expenditures. Furthermore, by reducing the scale and complexity of infrastructure projects, utilities may face fewer challenges from intervenors or regulators concerned with cost-effectiveness, affordability, and equity. These attributes position smart panels as a tool that may assist utilities in meeting electrification and decarbonization goals while supporting customer affordability.

For customers, smart panels can reduce the procedural, technical, and cost-related complexity of electrification. By avoiding the need for service upgrades, customers can add electric appliances and vehicles with fewer delays and less disruption to the home. Load management functionality allows households to shift usage away from peak pricing periods, offering opportunities for bill savings under TOU rate structures. Additionally, circuit-level visibility and control can provide customers with improved insight into energy consumption patterns, supporting more informed participation in demand-side programs or dynamic pricing options. These capabilities may also help individual households contribute to broader decarbonization objectives by making it easier and more cost-effective to transition to all-electric homes. As a result, smart panels may serve as a key enabling technology for equitable, scalable electrification across California's diverse housing stock.

Conclusion

As jurisdictions throughout the US continue to advance decarbonization goals, utilities and regulators face growing pressure to accommodate rapid electrification while managing the escalating costs and timelines associated with distribution system upgrades. This analysis demonstrates that utility ownership and deployment of SPAN Edge ISP can deliver meaningful value to both electric utilities and residential customers across a range of electrification conditions. For individual customers, SPAN Edge ISP consistently provides high net benefits on the order of $8,000 per panel driven by avoided panel upgrades, deferred service extension costs, and energy bill savings from managed load shifting. These benefits remain stable regardless of broader system deployment levels, underscoring the value proposition of SPAN Edge ISP even in isolated installations.

At the distribution system level, targeted SPAN Edge ISP deployment can significantly reduce infrastructure investment needs by deferring or avoiding upgrades to transformers, service lines, and feeders. Total utility benefits per panel range from two to seven times the installed cost of a SPAN Edge ISP, with the highest returns achieved when deployments are strategically sited in locations with constrained distribution capacity. Because distribution upgrades are often triggered in threshold increments, benefits do not scale linearly with increased adoption. Early installations can yield large per-panel savings by avoiding specific upgrades, while additional panels beyond the deferral threshold generate diminishing marginal returns, particularly for primary distribution infrastructure. At higher levels of deployment, aggregated load shaping across many customers can achieve the same level of peak reduction with less intervention and disruption to any individual household, thereby improving the customer experience in ways not fully captured in the quantified benefits and potentially moderating the apparent rate of diminishing returns.

As electrification from EVs increases, ISP deployment becomes even more valuable. A significant portion of grid value from SPAN Edge ISP is tied to managed EV charging, the most flexible and highest impact load. Total utility benefits increase with higher EV adoption levels, as additional load would otherwise necessitate system upgrades. That said, extremely high load growth can surpass even managed capacity limits, triggering some upgrades despite SPAN Edge ISP intervention. This effect reinforces the importance of aligning ISP deployment with areas that exhibit both high load growth and upgrade deferral potential.

Overall, this analysis supports the case for regulated utility investment in SPAN Edge ISP technology as a cost-effective, scalable tool to enable residential electrification while alleviating pressure on distribution infrastructure. Strategic deployment, guided by feeder-level constraints and electrification forecasts, will be critical to realizing the full value of this solution.

Path Forward

For utilities considering smart panel deployment, several design and implementation questions warrant attention. Chief among these is where to target installations to capture the highest system value, particularly in feeders approaching capacity thresholds or in areas forecasted for high EV adoption. Ownership and cost recovery mechanisms that align with the panel's role as grid infrastructure, similar to Advanced Metering Infrastructure (AMI) meters or transformers, as well as coordination with broader DER and demand flexibility strategies will also prove critical to the success of utility scale deployment of these types of assets. From a regulatory perspective, smart panels offer measurable system benefits that can be evaluated within existing cost-effectiveness frameworks, but deployment will require CPUC approval through new or existing funding channels, as detailed subsequently.

Funding Pathways

While emerging regulatory mechanisms, such as California's Distribution Investment Deferral Framework and increasing co-funding from state and federal grants, are gradually introducing new funding pathways, the majority of grid and distribution system investments in California today continue to occur through General Rate Case (GRC) filings and supplemental applications. Under the multi-year GRC planning process, investor-owned utilities submit their proposed capital expenditures for distribution system improvements to the CPUC for cost recovery through customer rates. Within this current funding landscape, there are three potential pathways for California IOUs to deploy SPAN Edge ISP panels at scale, while ensuring alignment with CPUC policies and cost recovery requirements.

1. Rule 15/16 Allowances for Service Line Extensions

California's Electric Rules 15 and 16 govern the design and cost responsibilities for new electric service extensions to customers.[28] These rules allow utilities to recover certain infrastructure costs through ratepayer-funded "allowances" provided to offset the cost of utility-side and customer-side service extensions. In cases where installing a smart panel will result in a lower cost to the utility than upgrading the distribution infrastructure the cost of the smart panel could be included in the costs the utility recover under Rules 15 and 16.

[28] CPUC General Orders and Electric Tariff Rules (Rules 15 and 16)

2. AMI 2.0 Investments

AMI 2.0 refers to the next generation of smart meter and grid data systems being proposed and deployed by California's IOUs. These investments go beyond meter upgrades to include integration with customer and grid-edge technologies such as smart panels, enabling real-time load control, disaggregation, and DER orchestration. Smart panels that can communicate with utility AMI systems and respond to dispatch or pricing signals could be treated as part of the broader AMI infrastructure ecosystem. Cost-effectiveness findings from this analysis suggest that smart panels could provide additional cost-test benefits relative to other proposed AMI 2.0 investments. If utilities propose smart panels as utility-owned or utility-managed devices that enhance the grid's visibility and responsiveness, these could be included as capital expenditures in AMI 2.0 proposals, pending CPUC approval through rate case or application proceedings.

3. Performance-Based Incentive Framework

Under traditional ratemaking practices, California utilities' have little financial incentive to reduce the costs of upgrading their distribution grids. The utilities are allowed to recover the full cost plus earn a profit off of the upgrades. This means programs that lower the costs of upgrades can also reduce utility profits. Performance-Base Incentives break this framework by tying utility revenue and profits to metrics beyond total capital costs. For example, the CPUC could design a program that ties utility revenue to the total energy the distribution grid can support or keeping peak load below specified targets. This type of metric would encourage the utility to seek lower cost solutions to meet load growth at individual homes and businesses. These lower utility costs would ultimately be passed on the ratepayers. Under this framework, utilities could justify the procurement and deployment of smart panels as a cost-effective and scalable tool to achieve performance metrics.

Appendix A. Detailed CE Results

Table 3 summarizes CE scores and net costs/benefits for the TRC, PAC, and PCT cost-effectiveness tests, in accordance with CPUC SPM guidance. E3 did not evaluate cost-effectiveness for the high EV and moderate BE adoption with low SPAN Edge ISP deployment case, as the number of SPAN Edge ISP panels were not sufficient to defer a primary distribution system upgrade. For the two cases with high deployment, SPAN Edge ISP was not cost-effective from the program administrator perspective on a per-panel basis. This is due to the diminishing marginal value of distribution deferral as deployment saturates, emphasizing the importance of targeting SPAN deployment in areas with clear grid upgrade triggers.

Table 3. Summary of CE Ratios and Net Costs/Benefits by CPUC Cost Test

Electrification Level	SPAN ISP Deployment	Metric	TRC	PAC	PCT
Moderate EV and BE Adoption	Low	*B/C Ratio*	*6.53*	*2.11*	*NA - no costs*
		Net Cost/Benefits	*$14,962*	*$6,869*	*$8,093*
	Medium	*B/C Ratio*	*4.41*	*1.18*	*NA - no costs*
		Net Cost/Benefits	*$9,228*	*$1,135*	*$8,093*
	Medium with 50/50 Cost Share	*B/C Ratio*	*8.08*	*1.18*	*6.58*
		Net Cost/Benefits	*$10,459*	*$1,135*	*$6,863*
	High	*B/C Ratio*	*3.94*	*0.98*	*NA - no costs*
		Net Cost/Benefits	*$7,956*	*-$137*	*$8,093*
High EV and Moderate BE adoption	Medium	*B/C Ratio*	*4.19*	*1.12*	*NA - no costs*
		Net Cost/Benefits	*$8,635*	*$718*	*$7,917*
	High	*B/C Ratio*	*3.81*	*0.95*	*NA - no costs*
		Net Cost/Benefits	*$7,592*	*-$325*	*$7,917*