COUNTDOWN TO 2045

REALIZING CALIFORNIA'S PATHWAY TO NET ZERO

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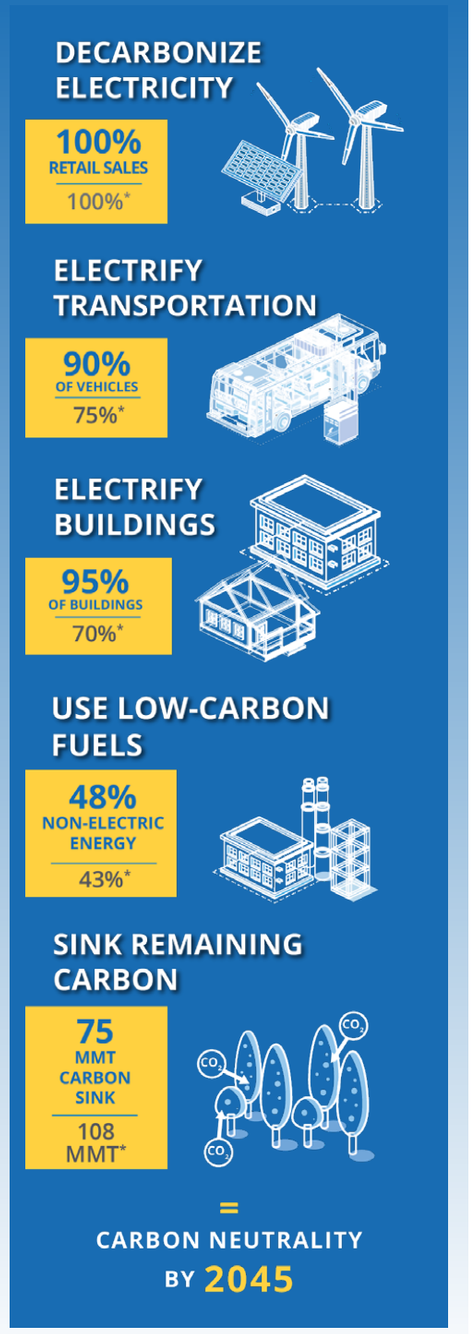


*From *Pathway 2045*, for comparison

EXECUTIVE SUMMARY

As people around the world face undeniable climate impacts and sobering risks to their future health and livelihoods, California's policy to achieve carbon neutrality by 2045 can be a model for other states and nations. However, success requires unprecedented innovation and coordination across planning, policy and technology. Significant electrification — powered by clean generation and enabled by an unparalleled expansion of the electric grid — is necessary to decarbonize the economy feasibly and affordably. Achieving this requires urgent and fundamental changes in how the state's entire energy infrastructure is planned and built.

Countdown to 2045 updates and expands upon Southern California Edison's 2019 analysis, *Pathway 2045*, incorporating policy updates, expected climate change impacts, market and technology developments and an in-depth study of electric sector reliability. Achieving net-zero greenhouse gas (GHG) emissions requires new and emerging technologies to play a large role, but the exact mix and scale remain uncertain. These technologies, including decarbonized fuels, clean and firm generation and carbon removal, must also be advanced while policies and regulations remain open to the full potential of emerging solutions.

California Assembly Bill 1279 is a primary driver of this new analysis by codifying into law the state's 2045 net-zero goal. It requires direct GHG emissions reduction of 85% by 2045. While achieving net zero is essential, meeting the deeper[i] emissions reductions mandated by AB 1279 and resulting from other policies drives changes relative to *Pathway 2045* that will be more challenging. These include nearly complete building electrification, greater reliance on emerging clean energy resources and electric grid expansion at an even more accelerated pace. These newest requirements limit options such as direct air capture and nature-based carbon removal, and thus may further increase the cost and difficulty of reaching net zero. While AB 1279 calls for an evaluation by 2035 of the feasibility and trade-offs of an 85% reduction, this paper identifies several feasibility challenges that must be taken into consideration quickly, likely well before 2035, as part of the state's ongoing evaluation of options to meet our decarbonization goals. Without significant policy change and technological development, they could impede our success. *Countdown to 2045* outlines near-term actions necessary to address these challenges and realize California's 2045 climate objectives.

The key findings below describe *Countdown to 2045*'s solution for California:

- 90% of light- and medium-duty and over 50% of heavy-duty vehicles are electric
- 95% of residential and commercial space and water heating is electric
- Over 3x more utility-scale clean energy resources are online compared to today, primarily through new solar, wind and energy storage
- Up to 15% of utility-scale generation is from new and emerging technologies, such as floating offshore wind and next-generation geothermal
- Distributed energy resources (DERs) play a key role, with 2x and 10x more distributed solar and storage, respectively, compared to today
- New transmission and distribution grid projects added at up to 4x and 10x their historical rates, respectively
- Low-carbon fuels support clean electricity generation and industrial sector GHG emissions reduction
- 75 million metric tons (MMT) of negative emissions technologies sequester remaining emissions

Achieving this transition will take over $370 billion of incremental transmission, distribution and utility-scale clean energy investments. Electric bills will increase due to higher use of electricity for transportation and buildings, but customer savings from reduced fossil fuel expenses will more than offset the increase. The average SCE household will save about 40% on their annual energy expenses by 2045 and benefit from cleaner air.

Countdown to 2045 describes a major leap in the pace of deployment in all aspects of the clean energy transition. This transition depends on **specific, near-term actions**, including:

System planning must be reimagined by state agencies and utilities for greater speed, efficiency, integration and flexibility

Emerging generation technology needs near-term investment to enable longer-term emission reductions

Process and regulatory reforms are necessary to accelerate transmission infrastructure development

Distribution grid evolution is required for utilities to serve electrification load and fully utilize local energy resources

California has already proven itself a climate leader. Edison International is committed to addressing climate change and offers the ambitious steps described here for California, and to set a strong example for others. While we applaud the state's recently passed clean energy legislation, further actions are required to ensure we reach our goal. Furthermore, similar transformation is needed worldwide to reduce global GHG emissions at a scale that will meaningfully slow climate change.

[i] Prior to AB 1279, Executive Order S-30-05 established a target for 2050 to be at least 80% below 1990 levels.

BACKGROUND

SCE's 2019 white paper, *Pathway 2045*, mapped out the energy implications of California reaching its 2045 net-zero goal. *Countdown to 2045* reinforces and builds upon the most affordable and feasible path identified in *Pathway 2045*, refining the necessary steps to achieve the state's newest, more ambitious decarbonization goals given technology advancements and adoption, deeper understanding of future climate impacts and improved reliability analysis.

Major policy developments since 2019 include:

Gov. Newsom's sweeping package of climate measures in 2022, including AB 1279

California Air Resources Board's (CARB) 2022 Scoping Plan Update[1], a key milestone that describes a state decarbonization pathway similar to *Countdown to 2045*

The governor's order for 100% zero-emission vehicle (ZEV) sales by 2035[2], paired with CARB's transformative requirements[3] in Advanced Clean Cars II and Advanced Clean Fleets

California Energy Commission's (CEC) Equitable Building Decarbonization Program authorized in 2022[4] with $1.1B in funding to reduce GHG emissions from buildings

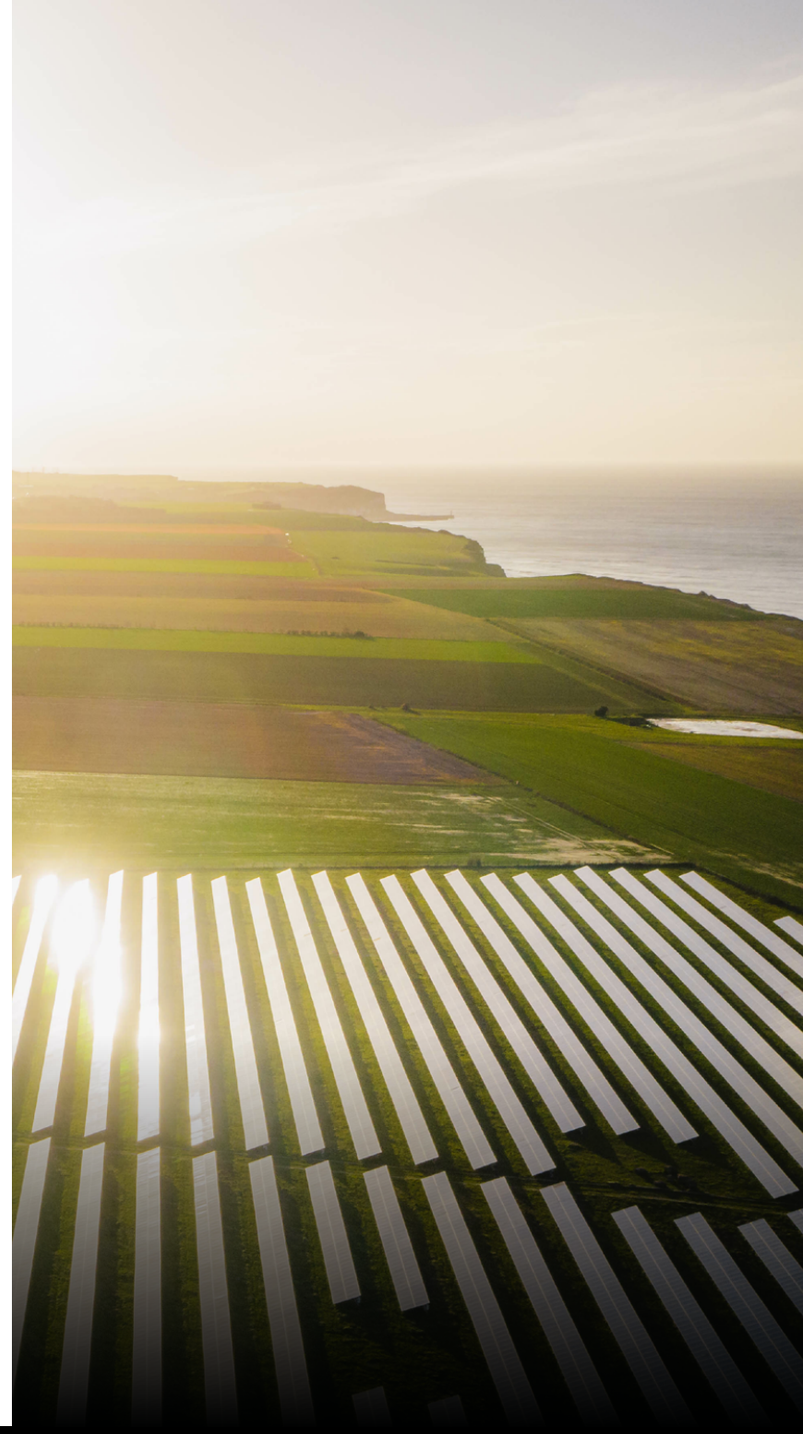
CEC's statewide offshore wind goal of 25,000 MW by 2045[5]

California Independent System Operator's (CAISO) first-ever 20-Year Transmission Outlook introduced in 2022, identifying $30B of needed transmission investments

CPUC's bolstered resource adequacy requirements to account for all hours of peak days and to raise planning reserve margins for system reliability

Markets and technology have seen complementary developments, including:

- **Accelerating consumer adoption of electrification** (e.g., light-duty ZEVs in CA increased from 6.8% of new car sales in 2019 to 25% by mid-2023[6]; electric appliances outsold gas appliances nationally for both water and space heating for the first time in 2022[7])
- **Growing momentum for emerging clean, firm resources** (e.g., dozens of next-generation nuclear and geothermal companies have collectively raised over $1B and received over $4B in awards from the Department of Energy; global project pipelines for electrolyzed hydrogen grew by 266% in the past year[8])
- **Infusion of government funding:** (e.g., the Inflation Reduction Act (IRA) allocates close to $400B of federal funding to clean energy through a mix of tax incentives, grants and loan guarantees that encourage private investment in emerging clean technologies and individual consumers to adopt EVs, heat pumps, rooftop solar and home batteries)



METHODOLOGY

SCE performed a sequence of six related analyses to determine the results shared in this paper. A detailed explanation of this methodology can be found in the Appendix at edison.com/countdownto2045.

1. An economywide GHG emissions analysis to determine the most feasible and affordable mechanisms for each economic sector to decarbonize in line with AB 1279 and SB 100 requirements[ii]
2. An hourly electric system load forecast to reflect the impact of electric vehicles, heat pumps and climate change, among many other factors
3. A capacity expansion analysis to select the optimal supply resource mix that economically meets demand and emissions targets
4. A reliability assessment to simulate load and generation uncertainties and iteratively adjust the supply resource mix until reliability thresholds are met
5. A determination of transmission and distribution infrastructure to effectively connect new generation and support increased demand
6. An estimation of generation, storage and grid resource costs to inform calculations on annual household energy expenditures

ii. SB 100 requires a 60% Renewables Portfolio Standard by 2030 and that carbon-free resources serve 100% of retail electricity sales by 2045.

MODELING OBJECTIVES

GHG by 2045
85%

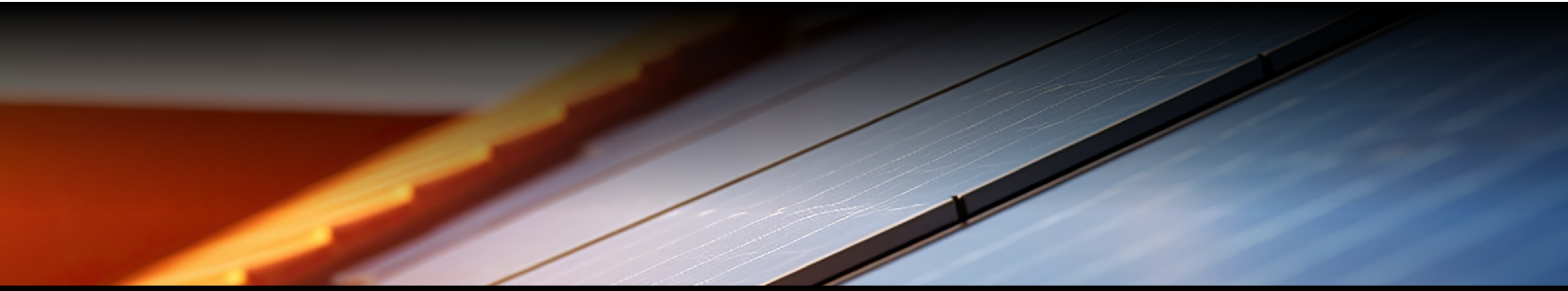
Meet GHG Reduction Requirements
Satisfy more stringent AB 1279 requirements of at least 85% reduction in direct GHG emissions by 2045

Ensure Reliability
Provide electricity at today's standard 1-in-10-year loss of load event threshold used in the state's Integrated Resource Planning

Ensure Feasibility
Assume realistic technology advancement and cost reductions; recognize value of emerging technologies and include where feasible

Maximize Affordability
Optimize the available options subject to the three constraints above for the most cost-effective solution

Note: these modeling objectives do not constrain the findings based on current policies; it is expected that policies will need to change to achieve this pathway.



KEY FINDINGS

UPDATED ANALYSIS

Since the publication of *Pathway 2045*, many studies have examined the path to carbon neutrality[9]. Despite a wide range of uncertainty, almost all studies share a common baseline — a set of proven technologies that must be deployed rapidly. This includes significant adoption of electric vehicles and electric heat pumps, and the associated infrastructure (such as onshore wind, solar, batteries and electric grid upgrades) needed to support this electric demand growth. In *Countdown to 2045*, electricity demand is projected to rise by over 80% from today, primarily due to electrification.

However, beyond this common baseline, the most feasible and affordable investments for remaining GHG emissions reductions become less certain. *Countdown to 2045* and many other studies use clean fuels (e.g., hydrogen, renewable natural gas, biofuels and synthetic fuels) in targeted "hard-to-decarbonize" applications, much of it potentially produced with clean electricity. These and many other promising clean technologies have yet to be affordably demonstrated at scale[10], including Carbon Capture and Storage (CCS), floating offshore wind turbines and vehicle-to-grid (V2G) energy, even as many will be essential to meet our net-zero goals.

Furthermore, AB 1279 requires an 85% reduction of direct emissions, thereby limiting the overall use of carbon removal technologies (e.g., direct air capture, nature-based carbon removal) to achieve net-zero emissions. Given the feasibility challenges associated with reaching net zero, consideration should be given to how this requirement limits a set of options that could enable a more feasible and/or affordable pathway to net zero.

However, *Countdown to 2045* addresses the existing AB 1279 requirements with the most cost-effective solutions based on today's information. This includes more extensive building electrification and reduced emissions from the electric sector when compared to the 2019 analysis, among other changes. Enabling these solutions requires additional investments in the power sector, both in generation capacity and grid infrastructure.

These changes, when coupled with a robust reliability analysis, show that energy supply will likely be most constrained in winter (when solar generation can be dramatically reduced during storms while heating demand is high). To address this gap, emerging technologies will be needed. Acknowledging the feasibility challenges, offshore wind is expected to be especially important at these times as it is likely to generate when electricity demand is high and solar generation is low. Additional needs include clean, firm generation (such as clean hydrogen, geothermal and next-generation nuclear),

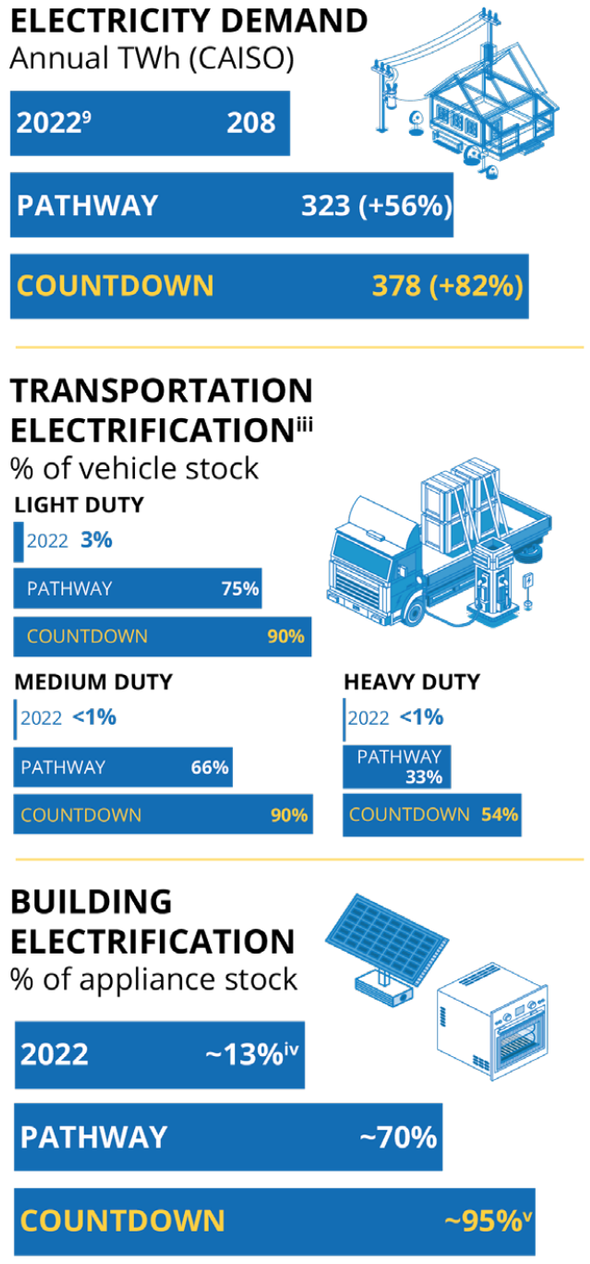


Figure 1: Electricity Demand in 2045

[iii] This paper assumes that 91% of heavy-duty vehicles are zero emissions vehicles (ZEV), with 54% being electric. All buses are ZEVs, 80% are electric.

[iv] Estimate derived from 2022 CARB Scoping Plan

[v] 100% of residential water heating, 94% of residential space heating, 98% of commercial water heating and 90% of commercial space heating assumed to be electric

	2022 Existing CAISO Resources	Pathway 2045	Countdown 2045
CAISO Resource Capacity	86	154	192
Gas	31	10	17
Solar	23	63	63
Storage (4-hour equivalent)	8	8	18
Storage (8-hour equivalent)	0	24	14[vi]
Onshore Wind	9	35	32
Offshore Wind	0	0	19
Clean firm	2	1	8
Other (e.g., hydro, biomass, demand response)	13	13	21
Incremental Cost ($B)	**N/A**	**$217B**	**$247B**

Figure 2: Supply Resources (installed capacity in GW)

supplementary load management and long duration storage resources and additional retention of existing natural gas capacity [see figure above].

The cost of the technology used to remove the final portion of emissions in 2045 is highly uncertain and will impact the overall affordability of meeting the net-zero target. The impact of increased building electrification and deeper electric sector GHG emissions reductions (relative to *Pathway 2045*) were each explored with a sensitivity analysis.

Lowering building electrification deployment from 95% to 70% reduces resource needs by 20 GW (demand response and about $13B of solar and battery storage) but increases GHG emissions from the building sector by almost 6 MMT. This fully mitigates winter energy sufficiency challenges. Similarly, when allowing the electric sector to emit up to 5 MMT more GHG emissions (which remains compliant with SB 100), 4 GW of additional gas generation may be retained through 2045, while reducing about $10B of solar, wind and battery storage capital investments (20 GW) and winter energy sufficiency issues are tempered. The wide potential range of increased costs due to corresponding emissions reductions elsewhere (e.g., industrial decarbonization or direct air capture) — to meet net-zero targets — is not included in these numbers.

Significant load flexibility is assumed in *Countdown to 2045*, which could be attributed to a variety of mechanisms including rate design and opt-in programs. Bulk resources include 6 GW of demand response and 2 GW of V2G. The underlying load shapes assume demand management as well; for electric transportation, over 80% of light-duty vehicle load is assumed to respond to TOU rates, price signals or load shifting mechanisms to minimize resource and grid buildout. To further explore the impacts of load management, sensitivity analyses were performed with an additional 15% to 30% of EV load shifted to match solar production. In these sensitivities, resource levels remained about the same with the need for 8-hour grid-scale batteries reduced by 6 GW. The overall resource buildout is driven by the underlying demand and the requirement for carbon-free generation.

GRID IMPACT

The load growth in *Countdown to 2045* requires a significant acceleration in grid expansion. New clean generation is needed both for new load and for decarbonizing supply for existing load.

CAISO system capacity has grown by about 2 GW/year over the last 20 years. Over the next 10 years, the CPUC's Integrated Resource Plan aims to add 7 GW/year, which will drive CAISO's planning for transmission expansion[11]. In the following decade, the pace of capacity expansion must increase to about 8 GW/year, on average, until 2045[12].

California's transmission system buildout must keep pace with systemwide resource capacity growth. Today, CAISO has 26,000 transmission circuit miles. To interconnect 120 GW of new resources, tripling bulk resource capacity, at least 20,000 circuit miles of 500 kV transmission must be added[13]. Deployment will need an investment of about $75 billion to interconnect CAISO resources, import out-of-state resources and bolster the subtransmission system[vii].

Providing electricity customers with 80% more energy in 2045 also requires the distribution system to expand significantly while simultaneously increasing the throughput and average utilization of the thousands of circuits already in use today.

Applying this scale-up to the SCE service area, the equivalent of 85 new distribution substations will be necessary. Furthermore, about 350 of approximately 900 existing substations will need to be upgraded to expand their capacity. Over 1,400 new distribution circuits will be required (if using designs that are standard today), which is about 30% more circuits than are in operation today. More significant upgrades to secondary service transformers and conductors will also be essential.

Altogether, expanding the distribution system to the scale needed in 2045 will require an incremental investment of about $50 billion statewide.

vi. 4-hour storage incorporates the CPUC Mid-Term Reliability requirement; additional 8-hour batteries were selected economically in the capacity expansion modeling.
vii. CAISO Capital Cost Estimates ($ in billions, 2023$) excludes distribution cost estimates.`

AFFORDABILITY

Solutions for achieving a net-zero economy in California will be durable only if they are affordable and no customers are left behind in realizing the benefits of electrification. The transformational investments necessary to decarbonize California's economy will create significant economic development, in addition to the clear societal benefits of dramatically reducing air pollution and addressing climate risks.

While additional electricity usage will increase electricity expenses, savings from reduced or eliminated fossil fuel expenses will more than offset the increase for households that adopt electrified technologies. Relative to what the average SCE household pays today for electricity, gasoline and natural gas, combined energy expenses decrease by about 40% by 2045. Households will benefit from these savings[viii] well before 2045, with the average household expected to see more than 10% savings by the early 2030s. All consumers in California must have reasonable opportunities to unlock these savings through electrification adoption; barriers including income and home ownership must be proactively addressed.[ix]

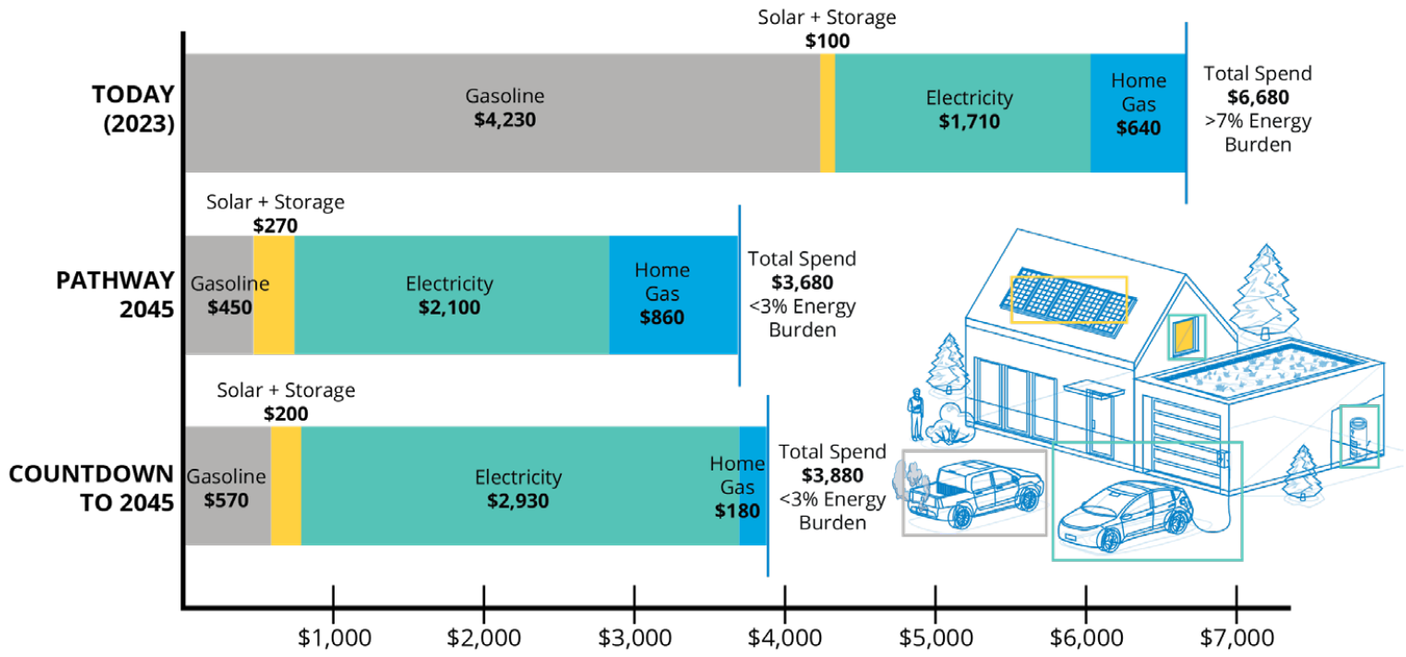


Figure 3: Average SCE Household Energy Expense (2023 dollars per year)

viii. The percent savings is approximate and directional because it relies on starting point that is highly sensitive to the widely varying price of fossil fuels. Expenses and savings are on a real basis of 2023$, accounting for inflation. See the Appendix, chapter 8 for more details.

ix. Vehicles and appliance costs are not included; electrification adoption is driven by natural replacement cycles. Barriers may also include space or electrical upgrades to customers' buildings.

ENERGY BURDEN

Energy burden is the proportion of household income spent on energy especially important for low- to moderate-income households, which typically face higher energy burdens and may face difficult choices between paying energy bills and for other basic needs.

FUTURE UNCERTAINTY AND OPTIONALITY

Although the main needs are well-established, some elements of *Countdown to 2045* are still uncertain and interdependent. These include transitioning nearly all buildings to electric appliances by 2045 (and implications for the future of the gas distribution infrastructure); creating and scaling a floating offshore wind industry on the West Coast; developing next-generation clean and firm supply resources such as geothermal or nuclear; and commercializing hydrogen, CCS and direct air capture technologies. Case in point: offshore wind and clean, firm generation are necessary to support very high levels of transportation and building electrification, but if those resources do not fully materialize, more natural gas generation may be the most feasible and cost-effective alternative, along with greater emissions reduction measures elsewhere.

Various journeys could be taken over the next two decades to arrive at an optimized 2045 solution, and changes in policy, technology, markets and society could shift the optimal mix of solutions across sectors of the economy in 2045. This analysis leaned on proven technologies to the extent possible in the optimized 2045 solution presented while complying with AB 1279; however, small changes can have dramatic impacts when solving for net-zero emissions.

Furthermore, breakthrough developments in areas such as industrial and agricultural decarbonization, or even the cost of carbon removal, could create more feasible and cost-effective, net-zero opportunities for California[x]. It is imperative that progress in these areas is monitored. AB 1279 and other climate policies and regulations should be regularly evaluated to ensure all options are open to achieve the most feasible and affordable solution.

[x] CARB's 2022 Scoping Plan estimates that abating 1 ton of carbon dioxide equivalent through direct air capture will be less expensive than additional electrification in 2045.

NEAR-TERM PRIORITY ACTIONS TO ACHIEVE NET ZERO

Achieving an 85% GHG emissions reduction and reaching net zero by 2045 requires bold, immediate action from all stakeholders across the public and private sectors. In 2021, Edison International published *Mind the Gap* with dozens of recommendations for policies to achieve 2030 emissions targets, based on the foundational *Pathway 2045* analysis. This paper builds upon those policy recommendations and broadens the lens to include planning and technology considerations, identifying near-term priority action areas across the electric system from bulk power to local resources.

REIMAGINE SYSTEM PLANNING

California must reimagine how it plans the electric system to efficiently interconnect clean energy resources and enable operational flexibility. The state needs a planning process that is integrated across domains (including generation, transmission, distribution and local resources) and objectives (including affordability, reliability, load growth and climate adaptation) to ease the process of interconnecting resources and enable a more resilient, cost-effective system.

Interconnection challenges have increased as more solar, wind and storage developments vie to connect to a transmission grid that must grow much faster. The volume of interconnection applications has more than tripled in recent years[14]. More than ever before, clarity is urgently needed to ensure the most cost-effective upgrades are built in time to interconnect new resources.

At the transmission level, California has begun to reimagine its system planning through proposed reforms to the CAISO generator interconnection process[xi] and through increased collaboration around zonal planning among the CAISO, CPUC and CEC[xii]. State agencies and system operators should build on these efforts by:

1. Instituting CAISO interconnection reforms that prioritize generator applications that demonstrate commercial readiness and utilize existing or planned transmission capacity
2. Expanding upon interagency zonal planning efforts to match clean generation development in geographic areas with transmission, lowering hurdles for deployment by ensuring commercial and permitting certainty

By attracting viable clean generation to areas with existing or planned transmission capacity, the state can simplify interconnection and transmission upgrade studies and promote timely transmission buildout at the scale required to meet our 2045 goals.

At the distribution level, integrated planning is necessary to optimally determine grid investments — considering evolving customer roles and expectations, new customer and grid technologies and significantly increased loads from electrification. The following are essential:

1. New software tools and technologies for planners to gather data and solve for multiple objectives, from load growth to climate adaptation to infrastructure replacement

2. CPUC-approved planning process including long-term (e.g., 20-year) forecast scenarios aligned with state decarbonization goals, and utilization of a flexible and expanded set of grid investments necessary to ensure timely interconnection for customers seeking to electrify

A holistic, systemwide view of planning is also needed to optimize investments and improve grid efficiency. This requires consideration of multiple forecasts that capture a range of realistic load growth possibilities. Investment planning must include DERs and load flexibility to increase optionality, minimize the risk of insufficient capacity and complement development of large-scale generation resources and new transmission infrastructure.

California should look beyond CAISO's borders to advance system reliability and affordability. Expanding CAISO into a regional transmission organization would give all participating Western regions access to an expanded set of clean resources to serve power needs during extreme weather or grid constrained events. Regionalization would also create a larger, more efficient market that would likely unlock more affordable sources of electricity and put downward pressure on customer rates.

xi. CAISO 2023 Interconnection Process Enhancements

xii. The CPUC, CEC, and CAISO signed a memorandum of Understanding in December 2022 which outlines their collaborative, zonal approach to transmission planning and generation development; SB 319, which was approved by the CA Legislature and sent for the Governor's approval in September 2023, proposes to strengthen this collaborative approach

ADVANCE EMERGING GENERATION TECHNOLOGIES

To reliably achieve net-zero emissions and SB 100 electric sector targets, the power supply resource mix needs to evolve significantly. In particular, changes in the profile and magnitude of system demand will drive an increased requirement for firm generation capacity. While solar and battery energy storage are experiencing strong growth in California's power grid, the day-to-day variability and seasonal production characteristics of solar mean they alone cannot meet future demand increases (such as for stormy winter mornings). Diversity of both resource type and location (with some resources close to load centers) will be essential to ensure the system remains both flexible and reliable.

California cannot afford to delay investing in the development of emerging technologies. Each has a complex journey from its current state to commercial feasibility, so the state must find innovative ways to accelerate development and deployment, reducing affordability impacts and risks of missing climate goals. Given best available estimates today, *Countdown to 2045* calls for 19 GW of floating offshore wind and 8 GW of clean, firm generation.

Offshore wind: California must grow a robust offshore wind industry to develop novel technology for floating turbine platforms and sea floor anchors, undersea transmission, specialized ports and vessels for installation and maintenance and a customized supply chain consisting of facilities that today take half a decade or more to construct[15].

Clean, firm generation: California will need to support a variety of nascent technologies:

- ***Clean hydrogen and long duration energy storage:*** Hydrogen can play several important roles in decarbonizing the economy, including as a fuel for clean, firm electricity generation and a form of long duration energy storage. Dramatic cost reductions for low- and zero-carbon hydrogen will be necessary for it to play a significant role in the statewide energy mix and further innovations are needed in transport, storage and combustion to safely realize its full value.
- ***Carbon capture and storage (CCS):*** Incentives such as the IRA[xiii] tax credits are helping the feasibility and scalability of CCS while SB 905 tasks CARB to create a regulatory framework for it. However, significant challenges must still be addressed, including inequitable air pollution impacts, safe and cost-effective transportation and long-term storage of captured carbon.
- ***Next-gen geothermal:*** California is rich with geothermal potential[xiv] and recent advancements in drilling techniques and subsurface exploration are creating opportunities to capture it. At least 30 geothermal companies have raised funding recently and will need support to reach commercialization at scale.
- ***Small modular nuclear reactors (SMRs):*** Since 1976, California law[xv] has effectively put a moratorium on new nuclear power plants. However, nuclear generation can be a carbon-free baseload resource with a small footprint and flexibility to be sited close to load. With safer, lower-cost reactor designs (Gen III+ and Gen IV[xvi]), next-generation nuclear technologies are getting closer to commercial readiness, but stronger state and federal support is imperative for these technologies to scale, resolve permitting issues and safely address the interim and permanent disposal of nuclear fuel.

While each emerging clean generation resource must overcome specific challenges, California should support measures to de-risk the development of all clean, firm technologies. State agencies may consider incentives or other mechanisms to help commercialization and reduce costs to California energy consumers.

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xiii. The Inflation Reduction Act of 2022 raised 45Q tax credits, which incentivize nvestments in carbon capture and storage, from $50/ton to $85-$180/ton or point source and direct air capture respectively.

xiv. Some estimates show <5% of a total ~60 GW potential is being utilized today. Source: Williams et. Al. study from the U.S. Geological Survey.

xv. Permitting of new nuclear power plants in the state only allowed if the CEC determines that the federal government has established a permanent site for the disposal of nuclear fuel (Source: CA Legislative Analyst's Office)

xvi. Gen III+ refers to improvements on current reactors (i.e., light-water); Gen IV are new/emerging reactor designs (e.g., liquid sodium).

REFORM PROCESSES AND REGULATIONS TO ACCELERATE TRANSMISSION INFRASTRUCTURE BUILDOUT

Since transmission infrastructure is the backbone of California's clean energy transition, urgent actions to accelerate its deployment must be given elevated priority, without waiting for developments with system planning or DERs.

The current grid infrastructure deployment process cannot keep pace with California's goals. Today, on average, greenfield transmission projects take 10-12 years to complete, with the permitting stage alone taking at least two to four years. Inefficient and undefined review timelines, redundant processes, excessive intervention periods and overlapping agency oversight have made permitting a significant bottleneck in transmission buildout. SCE's Tehachapi Renewable Transmission Project, for example, took six years to complete the permitting phase since the project had to obtain approval from the CPUC, U.S. Forest Service and nearby local communities.

Regulatory and policy reform in four key areas can help accelerate transmission buildout to the pace required:

1. **Advance policies that reduce permitting review timelines:** Imposing time limits of one year or less[xvii] for CEQA reviews and 270-day backend legal "shot clocks" can help speed project timelines while balancing the need for evaluating environmental impacts, incorporating stakeholder feedback and mitigating project risks.
2. **Eliminate redundant efforts in the permitting phase:** Identifying duplicative processes that occur when multiple agencies are involved in project permitting provides a chance to streamline further. Edison supported recent legislation to streamline need determination at the CPUC of projects that have been previously approved in the CAISO transmission plan. Additionally, recent legislation can help avoid duplicative reviews by granting permitting exemptions for projects that are not part of the bulk electric system, and further exemptions could be explored for upgrades or projects that have either previously been through permitting or will not have a material environmental impact.
3. **Minimize agency handoffs and appoint a lead agency for permitting reviews:** Many grid infrastructure projects are delayed because multiple state (and often federal) agencies must provide discretionary approvals. All transmission projects should have a lead agency appointed to minimize handoffs while ensuring stakeholder interests are satisfied. CEQA reviews typically have one lead agency already: the CPUC. However, the CEC may be best positioned to serve as the lead agency for CEQA reviews; they have a track record for executing transmission and distribution permits within 1-2 years. Recent legislation offers a pathway for transmission projects to opt in to CEC-led CEQA reviews. For projects requiring National Environmental Policy Act (NEPA) reviews, one federal agency should be obligated to lead the environmental review and consolidate interagency efforts to avoid duplicating environmental reviews. Additionally, the U.S. DOE's National Interest Electric Transmission Corridor designations could minimize state and federal conflicts with siting of new and existing transmission facilities.
4. **Standardize permitting at local levels:** Additional project delays and costs can arise during local government permitting reviews. De facto practices of local jurisdictions withholding ministerial permits can further delay transmission and distribution project timelines. California should establish an effective, standardized model to help local governments, communities and stakeholders collaborate with utilities to facilitate timely approvals of grid expansion projects while providing balanced opportunities for public involvement, similar to the California Governor's Office approach to accelerating EV charging deployment.[xviii]

These are important reforms that must continue to be instituted by regulators, policymakers and local governments. There is also a role for utilities to play. As grid operators, utilities should assure transmission lines are safely operating at maximum capacity and pursue upgrades to expand the value of existing rights of way in lieu of greenfield development. Additionally, utilities should pursue technology to make the transmission deployment process more efficient, such as automated line stringing devices, and continuing to evaluate grid enhancing technologies. Finally, utilities must engage communities early and regularly throughout the permitting review process.

[xvii] California Environmental Quality Act (CEQA) requires identification of significant environmental impacts of a project and plans to avoid or mitigate them, if feasible. One year time limits for CEQA reviews generally aligns with NEPA review time limits included in the U.S. Fiscal Responsibility Act of 2023.

[xviii] Under current law (GO 131-D), the CPUC must redetermine if a CAISO-approved transmission project is needed and issue a Certificate of Public Convenience and Necessity (CPCN), which can last 3 years.

PREPARE DISTRIBUTION GRID FOR LOCAL RESOURCES
Structural advances to the way the distribution grid is designed, built and operated will be necessary to meet the coming requirements. *Countdown to 2045* shows this includes nearly doubling the throughput while utilizing 2x more distributed solar and 10x more distributed energy storage. At the same time, the existing grid must be modernized, overall grid resiliency must increase in response to the rising frequency of extreme weather events and it must meet escalating customer expectations for service reliability.

Customers and electrification developers play a crucial role in all stages of this distribution grid evolution. They must:

- Communicate proactively with utilities about their needs and electrification plans to enable accurate load forecasting, especially for large projects
- Be able to make necessary upgrades to their property (e.g., electric panels) to electrify without undue financial and logistical burdens, regardless of income or home ownership

Distributed Energy Resources (DERs) are complementary to the bulk power resources discussed above; in aggregate, they provide flexibility that can reduce burdens on generation and transmission resources and can also provide more localized benefits for distribution grid reliability. Maximizing the value of these resources requires:

- Grid management technologies that effectively balance grid needs with DER capacity and a coordination framework between CAISO and utilities to leverage DERs effectively for both distribution and bulk power objectives
- Well-designed programs and incentives for key resources including solar, batteries and vehicle-grid integration

The foundational architecture of the distribution grid must be updated to optimally meet imminent needs. One key challenge is significant load growth within communities that are already built out and served by distribution infrastructure that is reaching physical capacity. The best solutions may incorporate new designs, such as higher distribution voltages, direct current and mesh distribution systems that can increase the capacity, reliability and resiliency of the grid, as well as increase coordination and integration with "at-the-meter" and "behind-the-meter" technologies. To support this evolution:

- Stakeholders from academia, national labs and the vendor community should re-evaluate today's grid assets and technologies considering innovative network architectures that solve for a variety of emerging grid needs

As described in "Reimagine system planning" above, integrated system planning is necessary to achieve this future state. Furthermore, utilities must enable flexible resources to optimally satisfy all requirements of the distribution system, including customer affordability, system reliability and resiliency, grid capacity readiness and further reductions in electric sector GHG emissions.

The four near-term priority action areas described here are critical to achieving California's net-zero target by 2045 while improving the feasibility and affordability of an 85% reduction in GHG emissions. A supportive economic and regulatory environment is also essential. It requires sending the right market signals to allow private entities, including developers, utilities and investors, to risk capital and continue funding aggressive growth with increased certainty. The clean energy workforce needs statewide investment to expand at an unprecedented pace.

If done collaboratively, affordably and equitably, this transition can unlock significant and long-lasting economic growth, creating a virtuous cycle that fuels further development and prosperity for California.

CONCLUSION

Achieving California's 2045 net-zero policy demands meticulous planning, transformative reforms and continuous innovation. The findings are clear: electric infrastructure buildout, including transmission and distribution, must happen rapidly and at an unprecedented scale as electricity demand will nearly double by 2045. Reforms in planning and permitting processes are imperative. Additionally, clean, firm generation will need to supplement wind and solar to maintain a reliable grid. It will be crucial for California to encourage commercialization and scale-up of emerging technologies. Optionality in achieving carbon neutrality is also key to maximizing savings and minimizing costs to all Californians, especially as technologies that are yet to be proven today will likely be relied upon.

Realizing California's 2045 net-zero goals requires a statewide plan supported by urgent, coordinated and decisive actions. Here at Edison International, we are committed to helping California reach this goal and we are ready to collaborate with all stakeholders to address the challenges ahead.

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Electronic copies of this paper and its appendix are available at edison.com/countdownto2045