



ACHIEVING AN EQUITABLE AND RELIABLE 85 PERCENT CLEAN ELECTRICITY SYSTEM BY 2030 IN CALIFORNIA

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PHOTO CREDIT

9.5 MW floating wind turbine deployed at Kincardine Offshore Wind project off coast of Aberdeen, Scotland. Photo courtesy of Principle Power.

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EXECUTIVE SUMMARY

California’s climate leadership starts with its electricity sector. The state has successfully navigated the transition away from coal, pioneered large-scale wind, solar, and battery projects, and led the United States in passing ambitious renewable portfolio standard (RPS) policies. In 2018 the state passed Senate Bill 100 (SB 100), requiring utilities to reach 60 percent renewable energy by 2030—which excludes nuclear and large hydropower generation—and 100 percent carbon-free electricity by 2045. Recognizing the maturity of wind, solar, and battery technologies along with electricity’s central role in decarbonizing the economy, the California Public Utilities Commission (CPUC) is now pushing utilities to go faster, effectively requiring them to reach 86 percent clean electricity by 2032.

A new technical report from GridLab and Telos Energy demonstrates how California’s sustained push to accelerate clean energy deployment will also help keep the lights on. The study complements existing reliability analyses by stress testing three 85 percent clean electricity portfolios against the most urgent reliability concerns, including the conditions that led to rotating outages in August 2020. The three portfolios are as follows:

1. A base case relying principally on onshore wind, solar, and battery storage.
2. A diverse clean resource portfolio including 4 gigawatts (GW) of offshore wind and 2 GW of geothermal in place of some onshore wind, solar, and battery storage.
3. A high electrification portfolio that includes the same amount of offshore wind and geothermal as the diverse clean portfolio but builds additional onshore wind, solar, and battery storage to reflect higher electricity demand from anticipated policy action to electrify transportation and buildings.

The technical analysis shows California can reliably operate a future power system that reaches 85 percent clean electricity in 2030, putting the state on a path toward its 100 percent clean electricity target sooner than 2045—potentially matching President Biden’s ambition of achieving a carbon-free electricity system in the U.S. by 2035, or at least supporting achievement of the proposed clean energy targets in SB 1020 of 90 percent clean by 2035 and 95 percent clean by 2040.

The technical report outlines how utilities and energy regulators can assess clean energy portfolios, showing how the CPUC’s integrated resource planning (IRP) process can incorporate simpler reliability models retaining enough hourly information in multiple weather years to assess cost and reliability implications of many possible portfolio variations. It also helps utilities and energy regulators understand how these portfolio variations might perform under certain stress cases and highlights possible applications of the study’s “stress test” approach for improving resource adequacy (RA) procurement.

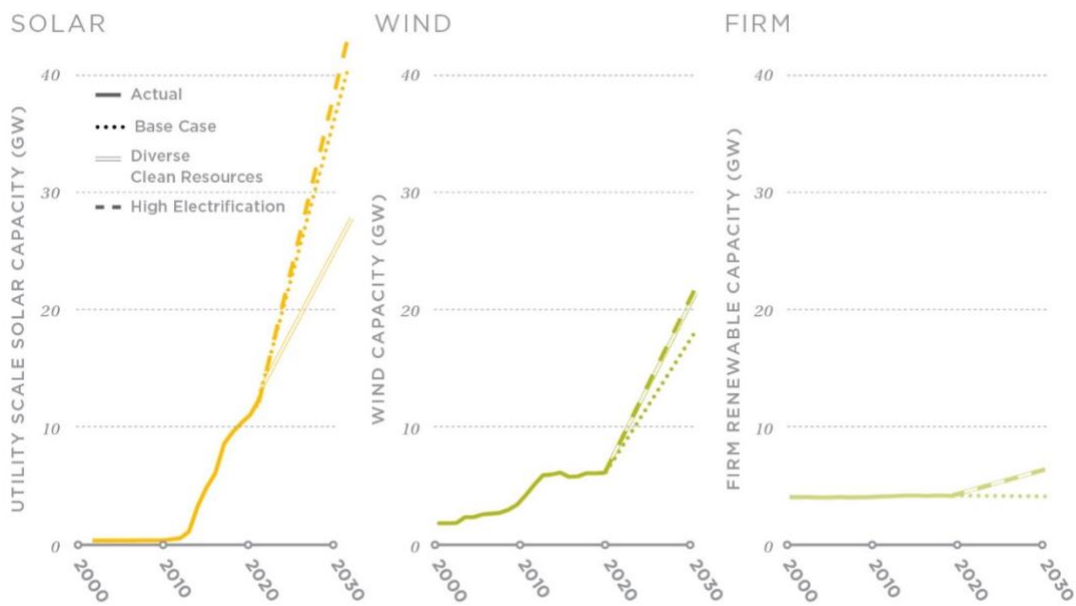
This policy report is a companion resource to the technical report, providing California policymakers with a set of no-regrets actions to effectively implement reliability insights from the technical analysis. Our recommendations show that policymakers can mitigate the risk of deploying resources too slowly, reduce the air pollution impacts of legacy natural gas power plants on disadvantaged communities (DACs), and foster resource diversity that improves reliability and reduces the amount of new power generation resources required to serve Californians. We propose policy measures around four key subjects to help realize these opportunities:

1. Accelerating and diversifying clean energy deployment
2. Reducing dependence on natural gas capacity
3. Leveraging demand-side resources
4. Improving regional coordination

Accelerating and diversifying clean energy deployment

While the technical analysis and similar CPUC procurement requirements point to the reliability of an 85 percent clean portfolio, the pace of deployment required to reach this mark by 2030 will be difficult to sustain without new policy.

Figure 1. Technical analysis deployment rates by resource and portfolio



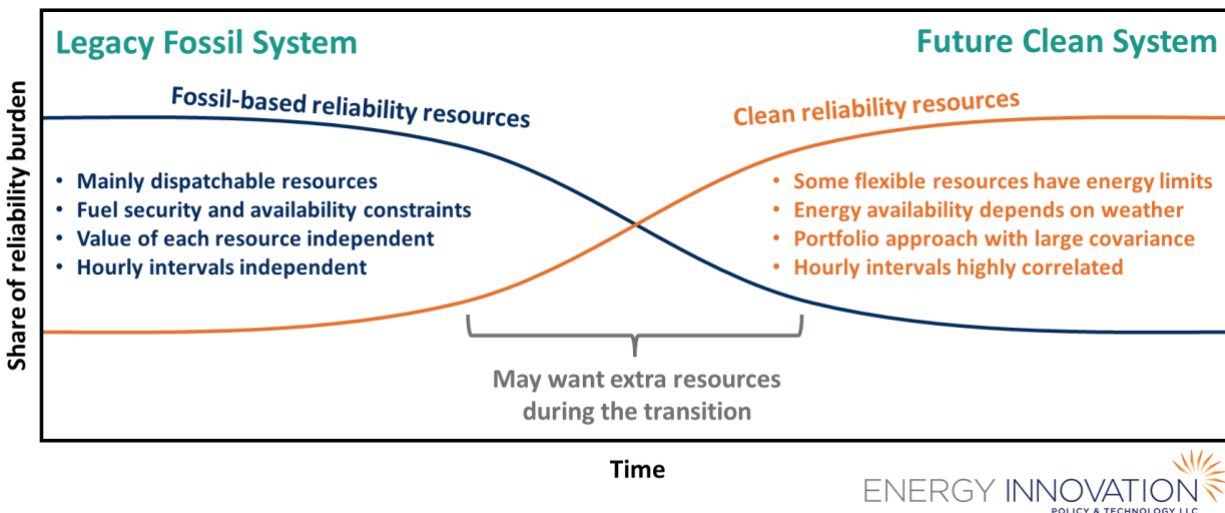
Including diverse clean resources like geothermal and offshore wind can reduce the deployment rate of utility-scale solar and onshore wind, all else equal. Source: GridLab and Telos Energy.

A more diverse portfolio with offshore wind and geothermal can reduce the risk of supply chain constraints as well as siting and permitting challenges that may worsen with high-enough solar, onshore wind, or storage resource build-out rates, suggesting it's worth increasing these resources' role despite their relative lack of technological maturity. We also highlight that proactive transmission planning and expansion can enable more clean energy deployment.

Reducing dependence on natural gas capacity

As California's share of renewable energy grows, its share of fossil energy must shrink apace. But experience has shown that adding more renewable energy does not necessarily retire more natural gas power plants. Thus, the central questions facing state policymakers are when and how to transition from natural gas to a suite of clean energy and demand-side resources providing the same or higher quality reliability services.

Figure 2. The paradigm shift in RA under the energy transition



California may benefit from overprovisioning resources to maintain a buffer through this transition.

Resource portfolios modeled in the technical analysis maintain reliability without building any new natural gas power plants, even after retiring almost one-third of California's remaining natural gas resources in 2030, but the modeling does not provide enough granularity to show particular gas plants that can be retired. As many natural gas plants are located in DACs, people living in these communities disproportionately experience the negative health effects from gas plant pollution.

Further, while total natural gas generation decreases in an 85 percent clean electricity system, more frequent cycling of natural gas power plants may cause greater instantaneous local pollution, risking a future where transitioning to clean energy exacerbates DAC air pollution.

Though not specifically modeled, electricity planners and regulators can advance environmental justice by prioritizing natural gas plant retirements in all DACs by 2030 at the latest. California should create a plan to systematically zero out its natural gas reliance as soon as possible while reinvesting in these communities. This plan should study local reliability implications of gas retirements, as well as avenues to overcome technical and policy coordination obstacles to building the appropriate clean energy alternatives.

Leveraging demand-side resources

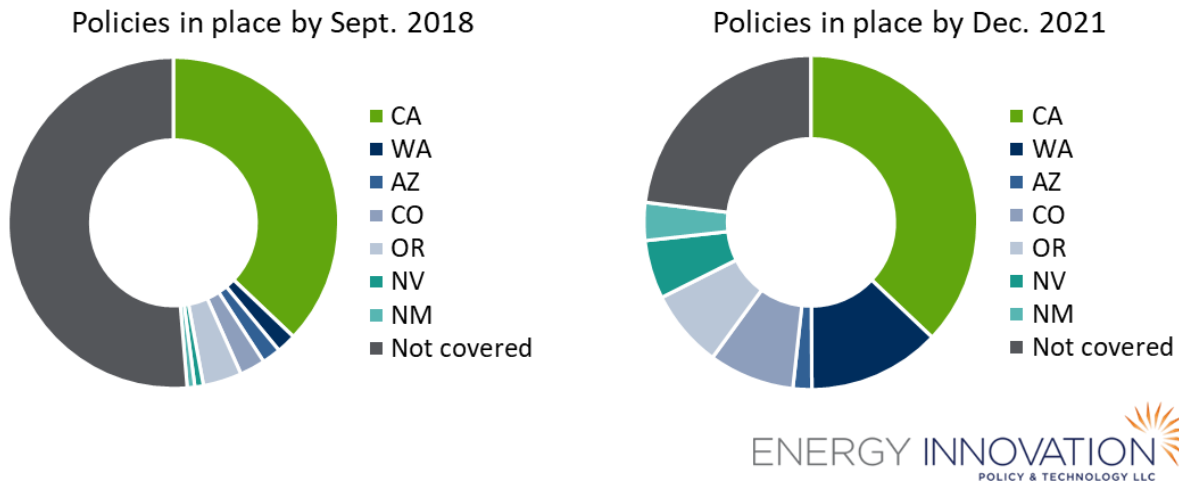
While the technical analysis doesn't directly examine forgoing building some new supply resources in favor of demand-side resources, it does include adding certain types of the latter as a sensitivity. Demand-side flexibility improves resource diversity, helping manage the deployment and operational risks associated with supply-side resources at lower total system cost on a faster timetable. As such, programs to expand and refine demand-side resources and markets are worthy of pursuing. These resources may also be able to facilitate more natural gas power plant retirements—specifically, we recommend the California Energy Commission (CEC) study how demand-side resources can match the value natural gas power plants provide in an 85 percent clean electricity system to help replicate and replace these gas plants.

Improving regional coordination

California will and should continue to import power from neighboring states to reliably achieve an 85 percent clean grid, though whether imports will consistently perform as desired remains a risk without greater regional coordination and transparency. As the rest of the West accelerates its decarbonization efforts, regional coordination will be increasingly important for adding resource and load diversity, maximizing the use of clean energy, making it easier and cheaper to trade electricity, and optimizing energy storage operations.

Thus, the California legislature should re-examine expanding the California Independent System Operator (CAISO) within the state and across the West and, in parallel, CAISO should continue its efforts to expand its market product offerings to other balancing authorities.

Figure 3. Share of Western states' 2020 electricity sales covered by state clean electricity policies



This figure applies future clean electricity targets to 2020 electricity sales (based on Energy Information Administration data) to demonstrate the growth in legislative commitments since 2018. It does not include utility commitments or the current share of clean electricity achieved in the “not covered” states (Utah, Idaho, Montana, Wyoming).

A clean, reliable grid for a safe climate future

This policy report’s recommendations form part of the foundation for California to achieve an 85 percent clean electricity goal by 2030—in line with what the U.S. must achieve to fulfill its commitments under the Paris Agreement and with emissions reductions necessary to stabilize the climate. Given the state’s resources and experience, the right risk management strategies can help California achieve a cleaner, affordable, and more reliable grid that enhances equity.

We recommend policymakers act on the technical analysis by considering the following recommendations that will help California attain a higher share of clean electricity by 2030 and diversify its means for doing so, securing a clean, reliable grid that benefits all its residents.

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1. INTRODUCTION

In 2018, California adopted SB 100¹—one of the nation’s first and most ambitious legislative requirements to achieve 100 percent zero-carbon electricity sales by 2045.ⁱ However, recent trends suggest the state must and can move even faster toward 100 percent. Recent reliability challenges, including wildfire-caused power outages and rotating outages in summer 2020, underscore that California must carefully manage this transition to protect its residents and maintain its global leadership.

This policy report offers recommendations for how state policymakers can set course for an 85 percentⁱⁱ carbon-free grid by 2030ⁱⁱⁱ and reach a fully clean grid by 2035 while supporting grid reliability and environmental justice. The policy report is a companion to a technical report from GridLab and Telos Energy that details the performance of three different 85 percent clean energy portfolios against a range of reliability “stress tests.” We recommend readers of this report also read the companion technical report.²

Chapter 1 highlights recent state successes and challenges in the clean electricity transition. Chapter 2 details the technical report’s most relevant findings as a foundation for policy recommendations in the subsequent four chapters. Chapter 3 focuses on what it will take to achieve an ambitious build-out of clean energy resources, including how offshore wind and geothermal resources can foster more achievable deployment rates. Chapter 4 highlights opportunities to prioritize natural gas retirements in DACs and orients agency actions toward this goal. Chapter 5 shows why policymakers should prioritize demand-side resources as a risk mitigation strategy. Chapter 6 demonstrates the role imports play in improving resource diversity

ⁱ In California, RPS compliance is determined by measuring renewable energy certificates as a percentage of retail sales, which creates about a 5 percent discrepancy between generation and retail sales due to transmission losses. In practice, this creates some ambiguity about whether 100 percent clean electricity by retail sales will allow for some portion of generation to come from fossil fuels. SB 100 also includes an interim target for electric suppliers to achieve 60 percent renewable electricity sales by 2030, which translates to roughly 70 percent clean electricity assuming the Diablo Canyon nuclear facility retires as scheduled and hydroelectric levels remain relatively unchanged from today.

ⁱⁱ The precise level of carbon-free electricity achieved in a year depends in part on available hydropower. All references to an 85 percent carbon-free goal for California assume similar levels of hydropower in 2030 as has been available in recent history (approximately 10 percent); in reality, a lower hydropower year may mean California achieves only 80 percent carbon-free electricity.

ⁱⁱⁱ On February 10, 2022, the CPUC voted to approve an administrative law judge’s proposed decision that lowered California’s statewide power sector planning target from 46 MMT CO₂e (consistent with a 60 percent renewable electricity requirement) to 38 MMT CO₂e by 2030 (which, “by 2032, includes the equivalent of 73 percent [renewable electricity] resources and 86 percent [clean electricity] resources in compliance with Senate Bill 100 goals”). This new target roughly aligns with the renewable (75 percent) and clean electricity (85 percent) shares analyzed in this report. “CPUC Approves Long Term Plans To Meet Electricity Reliability and Climate Goals” (California Public Utilities Commission, February 10, 2022), <https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-approves-long-term-plans-to-meet-electricity-reliability-and-climate-goals>; “Decision Adopting 2021 Preferred System Plan,” No. 22-02-004 (California Public Utilities Commission, February 15, 2022).

and reducing electricity costs, with insights for how to improve regional coordination so imports show up when the grid needs them most. Finally, Chapter 7 reaffirms the need for policies to help California navigate a rapid and equitable clean energy transition.

1.1 Reaffirming climate policy leadership

California has been a U.S. and global climate policy leader for decades and is working to improve equity and environmental justice. Four developments in the years since SB 100 passed demonstrate how the state can accelerate its power sector decarbonization goals while prioritizing environmental justice.

First, renewable technology and battery storage costs have continued falling dramatically.^{3,4} This has unlocked the ability to deploy clean energy faster at lower cost while improving air quality, advancing environmental justice, and creating jobs. A rapid clean electricity transition prioritizing gas retirements (along with accelerated electric vehicle adoption) would clear the air for the approximately 70 percent of Californians living in regions afflicted⁵ by high concentrations of ozone and fine particulate matter, especially for the top 25 percent most disadvantaged communities.^{iv} A faster clean energy transition would also reaffirm the state's position as a leader in clean tech development and deployment, bolstering its economy and bringing in new, lasting fair wage jobs.

Second, climate-driven disasters are tormenting Californians. Six of the seven largest wildfires in state history have burned since Governor Jerry Brown signed SB 100, including the Camp Fire, California's deadliest and most destructive wildfire on record.⁶ The Southwestern U.S. is now in its worst "megadrought" in over 1,200 years,⁷ and state reservoir levels have dropped to near-historic lows.⁸ 2021 was the state's hottest summer on record,⁹ with one analysis counting approximately 3,900 heat-related deaths in California over the last decade.¹⁰ New reports highlight the state's vulnerability to sea level rise, with as much as seven feet possible by 2100¹¹ but even half of that exposing critical infrastructure (e.g., wastewater plants and coastal power plants) to highly disruptive flooding.¹² Intensifying climate-driven crises accentuate the imperative to speed progress toward a decarbonized, resilient, and equitable grid.

Third, recent Energy Innovation¹³ and Edison International¹⁴ studies modeled California's current slate of policies, concluding the state is falling short of its mandate to cut greenhouse gas (GHG) emissions 40 percent from 1990 levels by 2030.^v These analyses, along with recent CPUC decisions, suggest the state must achieve between 80 percent to 83 percent clean electricity by 2030 to close the gap—in part because decarbonizing the power sector unlocks greater emissions reductions through electrifying other sectors by 2030 and beyond.

^{iv} Using CalEnviroScreen data.

^v Specifically, the studies find that by 2030 California would only reduce its GHG emissions by 33 percent to 34 percent from 1990 levels.

Finally, the rest of the U.S. will look to California and other leading states to set the national decarbonization pace. In 2021, President Biden set a goal for the U.S. to reach 80 percent clean electricity by 2030¹⁵ and 100 percent clean electricity by 2035.¹⁶ Achieving this target is essential to meeting the nation’s decarbonization commitment under the Paris Agreement, yet it is more ambitious than any existing state legislative requirement. Because partisan gridlock has prevented Congress from passing meaningful legislation to enact this target, states and utilities must lead the way.

In recent years, several states have matched or surpassed Hawaii’s and California’s clean electricity ambition, including New York’s law to achieve a carbon-free grid by 2040.¹⁷ Xcel Energy, a large utility in Colorado and the Midwest, has set a voluntary goal to reduce emissions 80 percent below 2005 levels by 2030.¹⁸ With improved clean energy economics and heightened urgency, California can provide a roadmap for action and galvanize other states and utilities to completely decarbonize their power systems by 2035.

1.2 Reducing pollution burdens for California’s most vulnerable populations

Despite the state’s remarkable success in reducing GHG emissions, California still suffers from the nation’s worst local air pollution. Even with the country’s most stringent and sophisticated clean air regulations, the state hosts 13 of the 20 most polluted counties in the country for ozone and annual particulates.¹⁹ On average, Black and Latino Californians breathe in about 40 percent more particulate matter from ground transportation than white Californians, and Asian Americans in California are exposed to about 20 percent more pollution.²⁰ This is happening alongside a housing crisis and rising energy prices, both of which also disproportionately affect low-income, non-white residents.

Though power plants are not the state’s leading cause of air pollution, primarily due to California eliminating coal from the grid, natural gas generators still emit significant harmful pollution. More than half of California’s gas plants are in DACs and U.S. Environmental Protection Agency nonattainment regions for air pollution.²¹ These gas plants exacerbate already inequitable health outcomes such as decreased lung function, more frequent emergency room visits, additional hospitalization, and increased morbidity, while also causing climate damage. Continued reliance on these plants jeopardizes any progress made reducing pollution from other sources, like heavy-duty trucks, especially for these communities.

1.3 Achieving a reliable and resilient grid

California has experienced several reliability threats in recent years, leading some policymakers to worry about the speed of the clean energy transition. However, these reliability issues are primarily tied to extreme weather events exacerbated by climate change, as well as regulatory and utility shortcomings in accounting for new risks. For example, an extreme heat wave and associated

planning shortcomings forced CAISO to apply rotating outages in August 2020 to balance supply and demand,²² dry and windy conditions have led the three largest investor-owned utilities (IOUs) to de-energize transmission lines to avoid sparking wildfires,²³ and lasting drought conditions have lowered the region’s hydropower assets.²⁴

Continued reliance on fossil fuels that cause climate change will only exacerbate long-term reliability threats, while fossil-fired power plants are nowhere near a silver bullet to mitigate short-term threats. For instance, high air and water temperatures reduce thermal power plant efficiency and availability.^{vi25} Meanwhile, wildfires and transmission line shut-offs incapacitate upstream power generators, raising the value of demand-side measures such as distributed solar, locally sited battery storage, and energy efficiency that support the grid closer to where customers are being served.^{vii}

However, mismanaging the transition to high clean energy penetration away from gas generation in a way that creates large-scale outages or fails to address environmental justice would severely impact residents and discourage other states from pursuing such targets. It is essential for California to build a reliable, inclusive grid that is supported by all residents on the road to a decarbonized economy.

A well-managed clean energy transition can make the system more reliable and more resilient to shocks. Renewable energy resources do not depend on fuel availability or expose consumers to volatile fossil fuel prices. Distributed resources, demand management, and improved coordination with other Western states could all help keep the lights on through challenging events.

As California undergoes this transition, it will certainly face unanticipated challenges requiring robust risk management strategies. However, as the state learns how to operate its power system under this new paradigm of predominantly renewable energy resources, it can accelerate its pace of legacy gas asset retirements. In sum, rather than compromising reliability and resilience, diverse clean energy resources can and should reinforce a reliable, resilient grid.

2. PUTTING POWER SYSTEM MODELING INTO A POLICY CONTEXT

GridLab and Telos Energy’s technical analysis of power system reliability provides policymakers with a lens to view tradeoffs between different resource portfolios and the feasibility of achieving

^{vi} In opening remarks for a workshop on improving natural gas performance, CEC Commissioner Douglas explained that in August 2020, “high temperatures and dispatch stressed multiple subsystems of the natural gas power plant fleet and resulted in de-rates and curtailments.” Transcript of December 2, 2020, Lead Commissioner Workshop in Docket on “Incremental Efficiency Improvements to the Natural Gas Fleet for Electric System Reliability and Resiliency.”

^{vii} While there is no such thing as “perfect capacity” (e.g., solar panels are also less efficient beyond certain temperatures), a technologically and geographically diverse portfolio of clean supply- and demand-side resources can mitigate system risks without worsening climate change.

an 85 percent clean electricity system by 2030. The technical analysis highlights the value of a diverse portfolio, opportunities to retire natural gas power plants, the value of demand-side resources, the risks and benefits of relying heavily on imports, and the system’s resilience to another West-wide heat event. We recommend any policymaker read the technical report as a companion piece to this policy analysis.

2.1 Technical analysis modeling approach

The accompanying technical report identifies interim targets (e.g., 85 percent clean electricity by 2030) for California on the path to 100 percent clean electricity by 2035. It uses PLEXOS modeling, which evaluates the power system’s ability to serve load on an hourly basis across all 8,760 hours of eight weather years. The analysis assessed the RA of California’s state-wide power system by first developing a set of clean energy portfolios—using the RESOLVE modeling tool,^{viii} which builds cost-optimized resource portfolios to meet constraints—and then stress testing the power system against factors such as retiring thermal generation, weather variability, demand flexibility, electrification, and import dependency.^{ix}

The technical analysis is a helpful supplement to the SB 100 analysis conducted by the Joint Agencies—consisting of the CPUC, CEC, and California Air Resources Board (CARB)—using the RESOLVE modeling tool without subsequent reliability analysis.^x It also matches well with recent CPUC resource and reliability planning for the next ten years of its jurisdictional demand (the large majority of all state demand).

The technical analysis provides additional insight into existing California reliability studies because it reveals the reliability value of different portfolios of clean energy resources. It models the collective behavior of multiple resource portfolios under various coupled weather and demand profiles without the extra computational costs of the probabilistic reliability analyses used in the California IRP process—a mode the technical report deems “stress testing.”^{xi} Stress testing considers the reliability implications of a larger set of possible build-outs under multiple sensitivities to achieve more cost-efficient but reliable procurement and optimize for more of the objectives or constraints regulators are balancing.

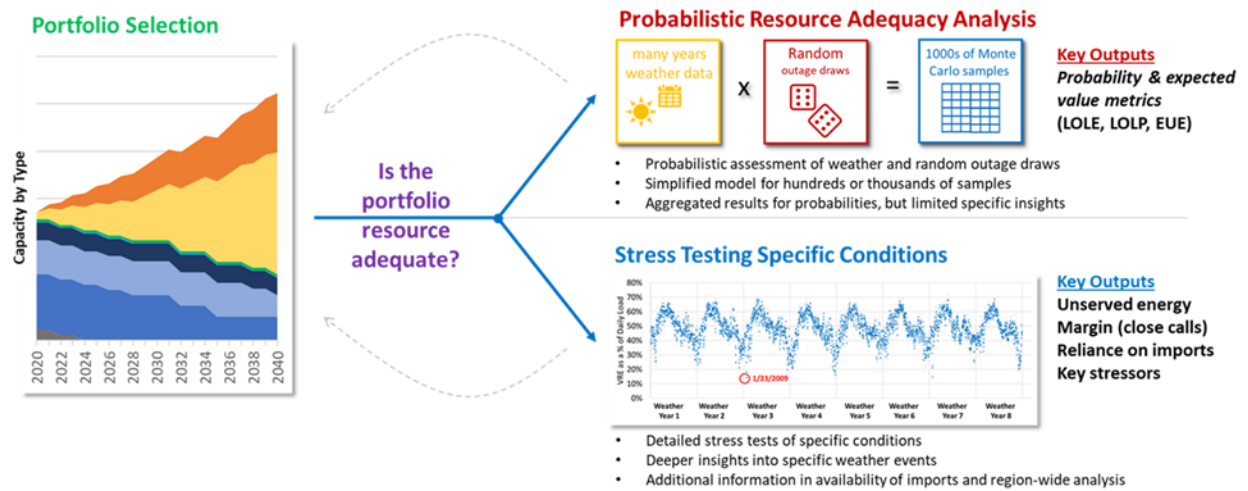
^{viii} These modeling tools are described more thoroughly in the technical report.

^{ix} The study takes a “stress testing” approach for assessing RA, rather than a conventional approach in which a single portfolio is assessed using probabilistic production cost modeling. These two approaches are described in the technical report and are complementary means for assessing RA.

^x These modeling tools are described more thoroughly in the technical report.

^{xi} See the “Differentiating resource adequacy planning and stress testing” section in the technical report.

Figure 4. Probabilistic analysis vs. stress testing approaches for RA analysis



Source: GridLab and Telos Energy.

2.2 Lessons for reliability modeling

Processes like the CPUC’s IRP should incorporate simpler reliability models like those used in the technical analysis that retain enough hourly information in multiple weather years to help assess the cost and reliability implications of many possible variations in procurement orders and understand how these might perform under certain stress cases or edge scenarios.

Part of the validation process for the IRP’s reliability included an exercise to ensure that the Preferred System Plan resulted in an adequate loss-of-load-expectation of less than one event in ten years.^{xii} However, this modeling is limited to relatively narrow scenarios and does not allow policymakers to assess the reliability tradeoffs between many different possible configurations without incurring significant costs.

Most current ideas under consideration to reform California’s RA requirements framework involve shifting from a dynamic reliability evaluation of whole portfolios to a static, bottom-up assembly of resource accreditation and validation schemes. In RA procurement, each resource under consideration will have an associated system RA credit for any given hour, month, or season that may be established in a manner considering only portfolio effects from an initial reference

^{xii} The CPUC used the SERVM model to validate its preferred system plan. The SERVM model leverages multi-year simulation of the power grid dispatch, along with a probabilistic treatment of possible natural gas plant failures, to assess the probability of an energy shortfall. The tradeoffs between modeling approaches are examined in more detail in the technical report, at page 16. See also <https://www.astrape.com/servm/> to learn more about the SERVM model.

portfolio. The reference portfolio is static because these values will not be adjusted dynamically as a function of the aggregate actual RA procurement from all parties. Examining portfolio performance in a “stress testing” framework similar to the technical analysis could help validate or improve this exercise.

2.3 Lessons for considering gas retirements

The technical report finds that California can reliably reach 85 percent clean electricity by 2030 through multiple resource pathways relying primarily on wind, solar, and storage, with the rest of generation coming from natural gas, hydropower, and imports.^{xiii} Relying on a diverse portfolio that includes 4 GW of offshore wind and 2 GW of geothermal as part of an 85 percent clean share helps reduce the risk of overreliance on solar and reduces the overall storage need.

Because of the incremental reliability contributions of renewable energy and storage, some natural gas capacity can be retired while maintaining acceptable reliability. Perhaps most notably, no new natural gas is needed despite forecast load growth or the retirement of the Diablo Canyon nuclear facility and once-through cooling plants. However, the technical report finds reliability benefits in maintaining most of these natural gas-fired power plants while running them much less frequently than today, which leads to significant GHG emissions reductions.

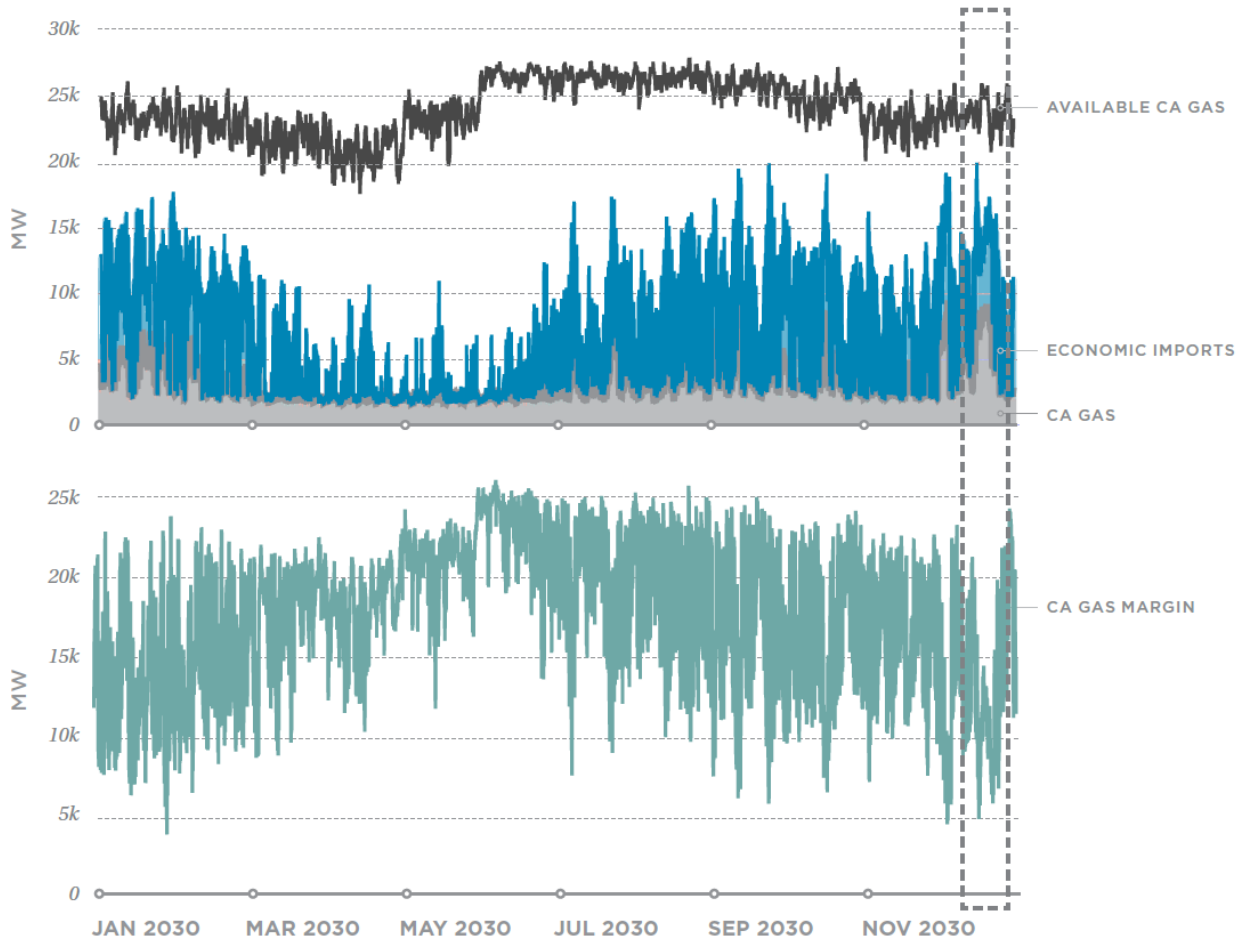
After accounting for the planned retirement of the once-through cooling natural gas facilities, the model’s core scenarios assume remaining existing natural gas power plants stay online, although infrequently relying on them.^{xiv} Two of the three core scenarios explore resource diversity by including offshore wind and geothermal, but in holding with the assumed constraint of achieving an annual average of 75 percent non-hydropower renewable energy, adding these resources primarily results in the model reducing the amount of installed solar capacity. The scenarios do not explore additional resources such as long-duration storage or hydrogen that would intentionally address some of the reliability services provided by the remaining natural gas units.

The technical report also develops its own reliability metric that compares a given hour’s use of economic imports (i.e., imports not tied to dedicated contracts for delivery) and in-state natural gas generation relative to the total available in-state natural gas capacity; the former being greater than the latter implies some reliance on imports to maintain reliability. However, the modeling tool does not seek to optimize the portfolio nor the dispatch around maximizing natural gas capacity retirements—the leading constraint is instead a 75 percent annual renewable electricity share.

^{xiii} The technical analysis built resources to achieve a constraint of approximately 75 percent renewable electricity; thus, by design, after accounting for existing hydroelectric generation, the only resources that could serve the remaining load are in-state natural gas-fired power plants and imports.

^{xiv} The negative air quality and health impacts of more gas start-ups and ramping are significant and are discussed later in this report.

Figure 5. In-state gas dispatch and economic imports, weather year 2010



Visual representation of the technical report’s “California gas margin” reliability metric, which nets out economic imports and dispatched California natural gas generation from total available California natural gas generation. In this example, the gas margin is positive in all hours, demonstrating California’s ability to meet demand without needing to rely on economic imports. The dotted box represents a low wind and solar event. Source: GridLab and Telos Energy.

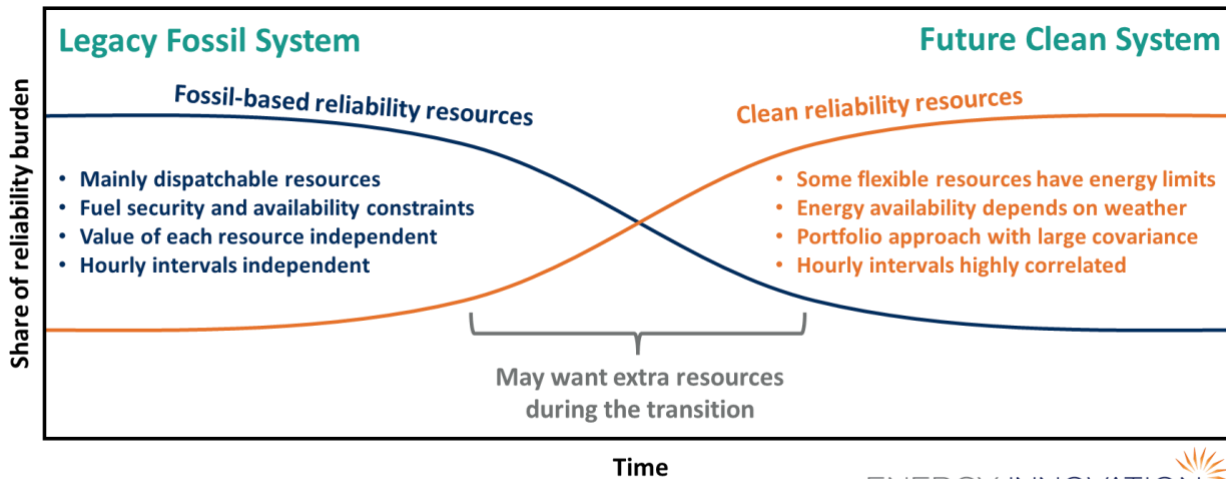
Because natural gas capacity is an exogenous variable, while the model finds that keeping California’s gas fleet available will maintain reliability through the transition to 85 percent clean electricity, it does not prove the inverse. In other words, the study was designed to identify pathways to meet an accelerated clean electricity target but was not designed to minimize the need for gas.

A key modeling sensitivity exploring natural gas capacity retirements suggests significant opportunities to retire existing gas while maintaining reliability. The sensitivity retires 11.5 GW of

gas (about one-third of the fleet) while holding constant the rest of the resource mix to meet an 85 percent clean electricity requirement. This roughly matches the amount of gas capacity in or near DACs within the 75th percentile CalEnviroScreen score (12.6 GW).

A natural tension emerges from these insights: How fast can the system add resources, and what does this mean for the need for natural gas? The technical report highlights an end-state in 2030 wherein significant natural gas can retire, but policymakers will only obtain the confidence they need to act decisively if they focus on investing in clean technologies and reforming policies to reduce reliability risks.

Figure 6. The paradigm shift in RA under the energy transition



California may benefit from overprovisioning resources to maintain a buffer through this transition.

These policymaker actions include aggressively building out clean energy capacity as the CPUC has directed utilities to do, but they also include greater investment in complementary demand-side resources as well as measures to improve confidence that imported power will deliver when it is needed.

2.4 Goals of this policy report

This policy report incorporates insights from the technical analysis to address how California can successfully navigate the clean energy transition. It offers policymakers a suite of no-regrets actions that can further strengthen reliability beyond what was demonstrated in the technical report and ensure the transition improves equity within the state. However, like the technical analysis, this report is limited in scope: While it focuses on reliability and RA challenges, it does not offer

recommendations on the very pressing issue of wildfire resilience, nor does it meaningfully examine a distributed energy resource-heavy development pathway for California.

The policy recommendations included in this report form part of the foundation for California to set and achieve at least an 80 percent^{xv} clean electricity mix by 2030—a milestone matching federal ambition that the U.S. must hit to achieve its commitments under the Paris Agreement. Reliability risks are manageable in this transition, and California has always led other states in successfully pushing the boundary of what is possible.

Given the state’s resources and experience, with the right risk management strategies, California can achieve a cleaner, affordable, and more reliable grid that enhances equity. We recommend policymakers act on the technical analysis by considering options that help California attain a higher share of clean electricity by 2030 and diversify the means by which it does so.

We organize our policy recommendations around four subjects grounded in key findings from the technical report:

1. **Accelerating and diversifying clean energy deployment:** Because a more diverse clean resource portfolio means less need for complementary dispatchable resources and more achievable deployment rates for new onshore wind, solar, and storage, policymakers must develop strategies to increase resource diversity and ensure timely deployment.
2. **Reducing dependence on natural gas capacity:** While at least some natural gas capacity can be safely retired while maintaining RA, agencies and utilities must develop new tools to ensure local reliability and advance environmental justice.
3. **Leveraging demand-side resources:** While growth in demand-side resources that shift the timing of when electricity is used is not strictly necessary with the sheer quantity of supply-side resources modeled in the base case, demand-side flexibility can help manage the deployment and operational risks associated with supply-side resources at lower total system cost and on a faster timetable, especially under higher rates of electrification.
4. **Improving regional coordination:** California will and should continue to import power to reliably achieve an 85 percent clean grid, though whether imports will perform as desired remains a risk without greater regional coordination and visibility. Regional replacement of coal plants with renewable energy and batteries—a proxy for how the rest of the West

^{xv} This report most often references an 85 percent clean electricity goal to allow California to still achieve 80 percent clean electricity in any given year even with low hydropower available.

may decarbonize—does not materially affect grid dependability in the technical report’s model.

3. ACCELERATING AND DIVERSIFYING CLEAN ENERGY DEPLOYMENT

In the past, policymakers have been able to mostly separate the process of growing the annual share of renewable electricity from that of maintaining reliability; however, two factors challenge this approach moving forward.

First, the technical analysis’s base case finds an 85 percent clean electricity mix is dominated by wind and solar resources—thus, there is much less room for other resources, especially legacy natural gas generation, to play a role in balancing the system. More attention in planning and procurement must go to complementary resources like batteries, geothermal, and offshore wind, and these resources should become an important part of procurement planning.

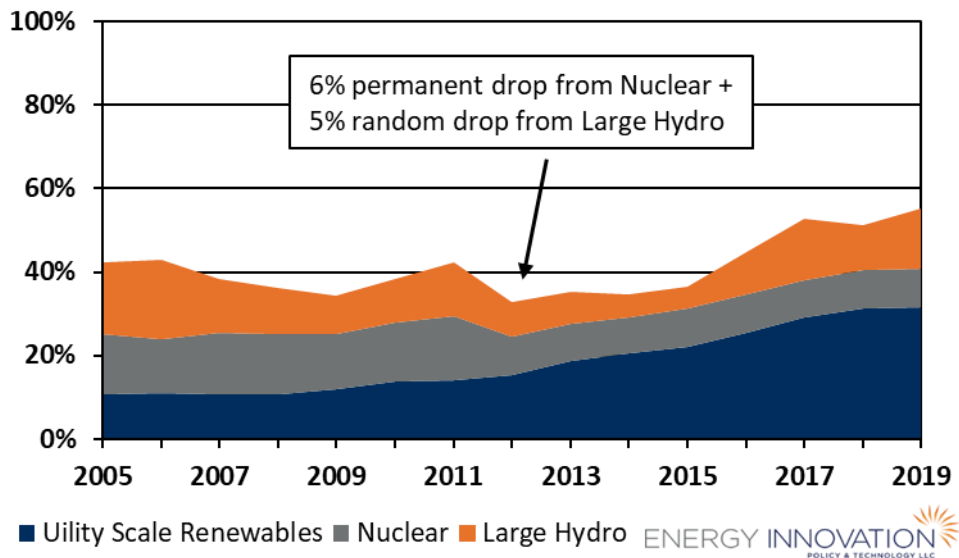
Second, following technical report insights, rapidly scanning through many possible portfolios using the stress test approach from the beginning becomes increasingly more important for procurement efficiency and reliability. It’s best to no longer plan procurement with cost as the primary consideration and then adjust from there to ensure RA; instead, planning should iterate so that RA is optimized from the start.

3.1 Background – Dominant renewables challenge the “RPS” mindset

Achieving an 85 percent clean electricity goal by 2030 requires a feasible but challenging step up in annual clean electricity from bulk generation. As the figure below shows, California has managed to increase its renewable electricity market share in bulk system generation from 11 percent in 2005 to 32 percent in 2019—an exceptional pace.^{xvi} Yet during that time, aggregated clean energy has only grown from 42 percent to 55 percent of all bulk annual generation serving the state market. Headwinds include larger annual fluctuations in hydropower, the loss of some nuclear power, and a recent slowdown in wind and solar deployment due to uncertainty about future needs.

^{xvi} In the same period, distributed solar photovoltaics production has gone from almost nothing to an additional 5 percent of the system mix.

Figure 7. Utility-scale clean power percentage of California mix



Source: California Energy Commission.

This slowdown is driven by the ongoing shift of customers from IOUs to community choice aggregators and early compliance with present interim RPS targets. SB 100 requires all utilities to procure 60 percent renewable electricity by 2030, then delegates development of interim targets and procurement to the CPUC from 2031 to 2045 to reach a goal of 100 percent carbon-free energy. While existing large hydropower and any new nuclear are not “RPS-eligible,” they qualify under the 100 percent clean standard. The RPS is an important complement to the CPUC’s IRP process, because unlike the IRP, the RPS imposes clearly enforceable requirements on community choice aggregators to meet clean energy goals.

Yet the weight of reaching 100 percent carbon-free electricity is beginning to stress the RPS structure. By their nature, RPS programs are concerned with energy—specifically, spurring investment in the lowest marginal cost clean electricity resources to produce more clean energy irrespective of contribution to system reliability or GHG emissions. As California gets closer to a fully decarbonized grid, the abundance of clean energy forces a change in the remaining resources that round out the system’s portfolio, which are outside the scope of the RPS. Difficulty retiring natural gas units is evidence of a recent policy shortfall.

SB 350 (2015) complements this by requiring CARB to develop a range of carbon emissions for the electricity sector in its Scoping Plan to guide the CPUC’s IRP process. In 2020, CARB recommended the CPUC adopt a 30 to 53 million metric ton (MMT) GHG target in 2030,²⁶ reflecting a range of scenarios for achieving California’s 2030 economy-wide GHG reduction target.

While the CPUC first embraced a target of 46 MMT, in 2021 it adopted a 38 MMT target^{xvii}—a level of ambition that would result in a reliable 74 percent RPS and 86 percent carbon-free electricity system by 2032. The CPUC’s decision to adopt a 38 MMT electricity sector target in 2030 suggests the Joint Agencies are already engaged in exceeding the 2030 RPS requirements of SB 100, closely matching the technical report’s ambition.

Reaching an 85 percent clean energy target will require more than just increased clean energy supply. If variable resources like wind and solar dominate future procurement, build-out of complementary resources like batteries or demand response (DR) must also proceed apace.

3.2 Insight – The value of resource diversity

The figure below shows the technical report’s base scenario more than doubles the state’s current rate of solar deployment and almost quintuples the rate of battery storage build-out. California achieved this wind and solar deployment from 2016 to 2017 but cannot afford the kind of slowdown the state witnessed from 2017 to 2019. This build-out challenge has already been identified by the Joint Agencies and CAISO in their September 2021 report to the governor.²⁷

The technical analysis’s modeled scenarios represent a further deployment acceleration, and meeting the bulk supply part of that challenge will require following a number of the recommendations in that report, including permitting, interconnection, and transmission planning reforms.

Under a more diverse portfolio (e.g., with more geothermal and offshore wind), the pace of wind and solar deployment is less daunting. The diversity also provides clear reliability and secondary advantages: less land use, fewer legacy resources needed, and less dependence on imports.

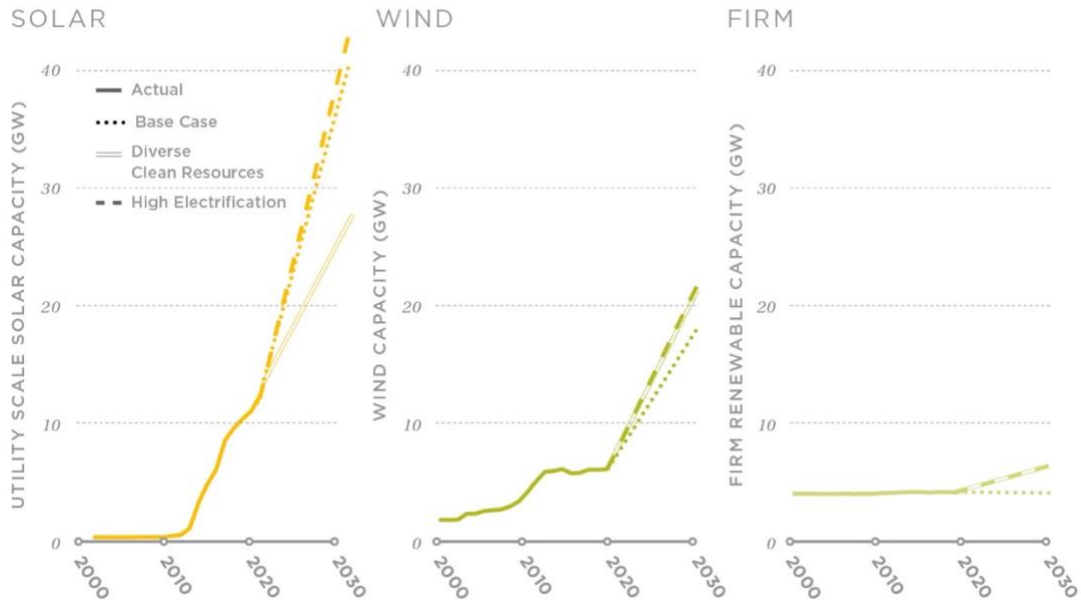
However, policy interventions are still required to shepherd these kinds of portfolios, as they don’t represent the path of least resistance, nor are they incentivized by SB 100. Higher unit costs for resources like offshore wind and geothermal require smarter integrated planning to incorporate their advantages. Offshore wind is still a nascent industry, especially the floating offshore wind turbines appropriate for California’s steep coastline; successful deployment of this technology will require incentives beyond the offshore wind road-mapping mandated by Assembly Bill 525 (signed in 2021), as well as help with siting and transmission.^{xviii} Supporting resource diversity may require extra up-front costs, but these costs will be offset by stimulating new energy industries in the

^{xvii} The CPUC also required utilities to submit plans to reach 30 MMT in the next two-year IRP process. See “Decision Adopting 2021 Preferred System Plan,” No. 22-02-004 (California Public Utilities Commission, February 15, 2022).

^{xviii} For current progress in integrating more offshore wind in the IRP, see slides from this recent meeting at the CPUC: “Roadmap for Offshore Wind in Integrated Resource Planning” (California Public Utilities Commission, December 17, 2021), https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/20211217offshore_wind_workshop_slidesv2.pdf.

state—with accompanying jobs and exports—and will set up California’s grid to more effectively reach decarbonization goals beyond 2030.

Figure 8. Technical analysis deployment rates by resource and portfolio



Including diverse clean resources like geothermal and offshore wind can reduce the deployment rate of utility-scale solar and onshore wind, all else equal. Source: GridLab and Telos Energy.

Transmission policy also risks falling behind as the pace of clean generation additions continues. Transmission is needed both to interconnect new resources onto the grid and to transfer large amounts of power from both in-state and out-of-state resources to load centers. CAISO is committed to meeting this challenge, but the need is urgent: The current interconnection request window, cluster 14, is looking at 373 requests compared to 155 last year. The interconnection queue logjam partly reflects the CPUC’s recent IRP orders calling for increased procurement. In a recent CEC workshop, CPUC Representative Karolina Maslanka said “transmission development will be necessary to accommodate the large amounts of resources expected to come online in the next 10 to 20 years to meet state goals.”²⁸

Fortunately, California’s energy policy apparatus recognizes, thanks in large part to sustained stakeholder input, that meeting the state’s climate goals requires moving faster in the electricity sector. The Joint Agency Report to the Governor on Reliability identifies institutional barriers,

including transmission and permitting, that slow California’s ability to procure these resources and reduce reliability risk associated with retiring natural gas and the Diablo Canyon nuclear facility.

In a sign of recent progress, on June 24, 2021, the CPUC ordered the procurement of 1,000 megawatts (MW) of “firm” clean resources (the services of which are modeled by geothermal in the technical report) and 1,000 MW of long-duration storage resources by 2026 (not included in the technical report).²⁹ This procurement, along with even more additional resources, was authorized in the CPUC’s ambitious Preferred System Plan in February 2022,^{xix} though it does not match the technical report’s ambition.

Table 1. New resource build-out of 38 MMT core with 2020 Integrated Energy Policy Report demand and high electric vehicle penetration (cumulative MW)³⁰

Resource Type	2022	2023	2024	2025	2026	2028	2030	2032
Gas	-	-	-	-	-	-	-	-
Biomass	34	65	83	107	107	134	134	134
Geothermal	14	114	114	114	184	1,160	1,160	1,160
Wind	1,697	1,719	2,049	3,531	3,531	3,531	3,531	3,531
Wind on New Out-of-State Transmission	-	-	-	-	-	-	1,500	1,500
Offshore Wind	-	-	-	-	120	195	195	1,708
Utility-Scale Solar	3,094	6,549	7,750	11,000	11,000	11,397	14,342	17,506
Battery Storage	2,565	4,604	9,811	11,317	11,317	12,078	12,395	13,571
Pumped (long-duration) Storage	-	-	-	-	196	1,000	1,000	1,000
Shed Demand Response	151	151	353	441	441	441	441	441
Total	7,555	13,202	20,161	26,511	26,897	29,937	34,698	40,551

Source: California Public Utilities Commission.

The SB 100 Core Planning scenario underpinning CAISO’s draft 20-year transmission plan (released in January 2022) also includes 10 GW of offshore wind by 2040 as core to the state’s clean energy goals.³¹ These actions suggest agency alignment with the technical report’s findings, especially on

^{xix} The 38 MMT “core” of the PSP includes 195 MW of offshore wind by 2030, and 1,708 MW by 2032. See Table 2 in Decision Adopting 2021 Preferred System Plan.

the benefits of resource diversity and its intuition that offshore wind is likely key to reliably and cost-effectively meeting California’s clean energy goals.^{xx}

3.3 Policy recommendations – Building a diverse portfolio

In working to accelerate clean energy deployment and ensure resource diversity, California policymakers should focus on three categories of actions they can take.

First, the CPUC should actively guide the “right” mix of clean resources on the supply side. The CPUC should expand on the work of the Joint Agencies, CAISO, and the Governor’s Office of Business and Economic Development (GO-Biz) to address barriers to resource procurement through tracking, identifying, and resolving issues with individual projects that are critical for the transition to a clean and equitable energy future.

The CPUC should also incentivize more diverse supply (like offshore wind and geothermal) and more demand-side resources, focusing on the IRP proceedings. Some positive steps—like the order for 2 GW of “firm” clean and long-duration storage resources—have been taken, but more will be required to fully decarbonize. In general, the CPUC should over-procure clean resources by embracing bullish electrification forecasts and taking advantage of near-term tax incentives and low borrowing costs. Electrification will accelerate sooner or later to meet state climate goals, so it’s best not to be caught unprepared.

Second, while the CPUC electric sector IRP processes already incorporate a portfolio approach to procurement at the bulk system level, the CPUC should work with the CEC and CAISO to further improve them. These entities should incorporate modeling approaches like the ones used in the technical analysis to stress test many possible portfolios against known extremes before selecting a preferred portfolio to test with more stringent reliability analysis. This includes using similar simple 8,760-hour models, across many weather years, to evaluate the aggregate system RA procurement, especially against periods of possible stress.

These entities should also work with the research community and other stakeholders to develop new methodologies that create a more dynamic approach to the RA accreditation, evaluation, and settlement system. This should include work on energy sufficiency given the rising dependence on use-limited resources like batteries. Relatedly, these groups should work together to better characterize system risk from reliance on economic imports and create representative stress scenarios to include in the multiple runs of simpler reliability models. This work includes better incorporating climate trends into the data, including their impact on transmission risk posed by wildfires, low or extreme hydropower conditions, and extreme regional loads during heatwaves.

^{xx} For a more detailed look at transmission issues and recommendations for California, see Rob Gramlich et al., “Resolving Interconnection Queue Logjams: Lessons for CAISO from the US and Abroad” (Grid Strategies, LLC, October 2021).

Third, the CPUC, CAISO, and California’s utilities should work to ensure enough matching transmission is built to accommodate new clean energy resources and seek to prioritize projects in the crowded interconnection queue. Specifically, these entities should coordinate with the CAISO transmission planning process to increase transmission and develop more least-regrets solutions that can meet the needs of multiple deployment scenarios, while also giving proper weight to distributed resource alternatives.

While adding new resources is welcome from a reliability point of view, policy attention should be given to where resources will be built. Currently, open-access queue rules don’t allow optimization of resource placement with reliability and land-use concerns when it comes to prioritizing queue order. Planners should account for specific generation profiles and locations as related to reliability when prioritizing projects in the interconnection queue, along with prioritizing shovel-ready projects for interconnection when possible.

Responsibility for the future supply mix is shaped by direct legislation and regulation, but resource procurement and retirement decisions ultimately must be undertaken by utilities. These decisions must account for choices that utility customers make to electrify their energy use in buildings and transportation and adopt distributed energy resources. Smart, inclusive policy will have to cover the gamut of stakeholders.

Table 2. Policy recommendations to accelerate and diversify clean energy deployment

Decision-maker	Policy
CPUC	<p>Within the IRP, actively help guide the “right” mix of clean supply-side resources:</p> <ul style="list-style-type: none"> ● Continue and expand on the work of the Joint Agencies, CAISO, and GO-Biz to address procurement barriers through tracking, identifying, and resolving issues with individual projects that are critical for transitioning to a clean and equitable energy future. ● Incentivize more diverse supply (like offshore wind and geothermal) and more demand-side resources, focusing on the IRP proceedings. ● Err on the side of over-procurement, in part by embracing bullish forecasts of vehicle and building electrification.

<p>CAISO, CEC, CPUC</p>	<p>Work to improve the IRP process:</p> <ul style="list-style-type: none"> ● Incorporate reliability modeling methods like those used in the technical analysis that retain enough hourly information in multiple weather years to help assess cost and reliability implications of many possible variations in procurement orders, to gain intuition of how these might perform under certain stress cases. ● Use 8,760-hour reliability models, across many weather years, like the ones used in the technical analysis, to evaluate the aggregate system RA procurement, especially against periods of possible stress. ● Work with the research community and other stakeholders to develop new methodologies to create a more dynamic approach to the RA accreditation, evaluation, and settlement system. This should include work on energy sufficiency given the rise of use-limited resources like batteries. ● Work with the research community and other stakeholders to develop a better characterization of system risk from reliance on economic imports and create related representative stress scenarios to include in the multiple runs of simpler reliability models. ● Seek to better incorporate climate trends into the data, including their impact on transmission risk posed by wildfires, low or extreme hydropower conditions, and extreme regional loads during heatwaves.
<p>CPUC, Utilities, CAISO</p>	<p>Coordinate with the CAISO transmission planning process to increase transmission and develop more least-regrets solutions that can meet the needs of multiple deployment scenarios.</p>
<p>CAISO</p>	<p>Reform the interconnection queue process to prioritize valuable locational attributes of proposed projects.</p>

4. REDUCING DEPENDENCE ON NATURAL GAS CAPACITY

The inclusivity and justice of California’s clean electricity transition depends on ending the use of fossil generation, starting with plants located in DACs. Reducing reliance on legacy natural gas power plants is also key to reducing system costs; maintaining reliance on seldom-used gas is a potentially expensive reliability solution if clean energy portfolios can displace the need for many of these plants at lower cost.

Retiring natural gas power plants has historically been difficult. Policy that affects the future lifespan of legacy gas is spread over many silos, in part due to the diversity of benefit streams from retiring gas and in part due to local reliability concerns. Moving forward, the technical analysis clearly shows room to retire significant gas at the system reliability level—enough to offer direct relief to DACs currently bearing the brunt of local air pollution impacts.

This relief should be a top priority for electricity regulators, and more effort must be made to develop and procure cleaner alternatives to gas as a reliability resource so that California doesn’t remain dependent for long on a stubborn remnant of gas.

4.1 Background – The gas retirement challenge

California law now requires energy agencies to address environmental injustice through regulation.^{xxi} So far, the agencies have made significant progress but have not always lived up to these mandates. For example, the CPUC Draft Environmental and Social Justice Action Plan identifies shortcomings and potential actions to improve environmental justice through utility regulation and investments. The CPUC has begun holding load-serving entities (LSEs) accountable in the IRP proceeding as well—the February 2022 IRP decision found that many LSEs were deficient in meeting DAC requirements and required more robust examination of environmental justice impacts in future plans.³²

Though this report focuses mostly on supply-side investments to deal with the impact of natural gas plant pollution, environmental justice includes ensuring community resiliency, building clean resources with job and economic benefits in communities, using a more local consultative approach in selecting new investments, and not building polluting resources in communities. Retiring gas implies significant spare transmission capacity to reinvest in clean energy resources in the same communities.

^{xxi} A full account of the CPUC’s obligations and historical efforts to account for environmental justice in its decision-making is available at “Environmental & Social Justice Action Plan Version 2.0,” Draft Version for Public Comment (California Public Utilities Commission, October 26, 2021), 7-8, <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/news-and-outreach/documents/news-office/key-issues/esj/draft-cpuc-esj-2010262021c.pdf>.

Particular to natural gas in or near DACs, the Joint Agencies have had difficulty developing effective methods to comprehensively consider system-wide resource needs while also considering hyper-local resource impacts on public health. Local Capacity Requirements (Local RA) for electric utilities are a main reason natural gas capacity is so sticky. Under Local RA rules, IOUs sign contracts with RA-qualified resources in certain pockets of the grid where CAISO determines a local reliability need exists. These contracts are nearly entirely for natural gas and provide substantial revenue based on the plant’s capacity, supplementing revenue from energy contracts and competitive energy markets.

The CPUC uses the RESOLVE model to assemble resource portfolios that reliably meet California’s power sector carbon goals. But like the technical analysis, these are regional assessments—there is no direct planning process by which the CPUC, CAISO, or any other agency explicitly assigns LSEs the obligation to procure these same clean resources near DACs to displace the reliability contributions of natural gas plants.^{xxii} In fact, local reliability needs are not considered as part of the IRP process. The status quo is resource procurement on a separate track from RA procurement, and without marrying the two, new resource procurement will continue to fall far short in displacing gas in DACs.

California does have at least one model for using clean energy resources in place of natural gas to meet Local RA requirements. In 2016, the CPUC approved the Puente natural gas power plant in Oxnard, set to begin commercial operations in 2020; however, sustained local advocacy and outside analysis made the case that a clean replacement portfolio could serve the reliability need, which led CAISO in 2017 to articulate the specific Local RA need and what could fill it. The CPUC then oversaw a portfolio assembly process, leading a combination of batteries, DR, and local voltage support to replace the plant.^{xxiii} This process provides a potential model linking procurement to other Local RA needs in the future.

4.2 Insight – The potential for gas retirements in California

A conservative approach to the clean energy transition that fails to prioritize equity would allow legacy natural gas resources to serve as “training wheels,” while policymakers, system planners,

^{xxii} The three IOUs serve as central procurement authorities for Local RA on behalf of all LSEs. For a resource to compete against natural gas for a Local RA contract, it must interconnect to that specific area of the grid—a major risk for new generators. But the more than 30 LSEs with obligations to procure resources under the IRP face no requirement and gain no financial benefit from procuring resources that would displace natural gas plants’ role in providing Local RA. Even if they had proper motivation, the IRP and RA proceedings do not yield specific information that LSEs can use to procure the right amount of capacity that would provide the needed Local RA.

^{xxiii} For a summary of the alternative portfolio and procedural history, see “Decision Regarding Southern California Edison Company 2018 Local Capacity Requirements Request for Proposals for Moorpark Sub-Area Pursuant to Decision 13-02-015,” No. Application 19-04-016 (November 15, 2019), <https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M319/K752/319752925.PDF>.

and operators build the clean system and learn how to manage a new reliability paradigm that adapts to the changing resource and technology mix. But the urgency of transition is existential to people living in DACs where many natural gas plants are located. An alternative, more equitable future would expend every effort to prioritize natural gas plant retirements in DACs by 2030 at the latest and systematically zero out the state’s reliance on natural gas as soon as possible.

The technical report’s model is able to maintain reliability through a rapid clean energy transition by keeping existing natural gas-fired power plants online and running them sparingly to manage remaining gaps in renewable output. For each scenario, the technical report also examines the reliability implications of retiring 11.5 GW of natural gas capacity—about one-third of what remains by 2030—in an 85 percent clean portfolio, finding these portfolios remain reliable. This gas sensitivity does not examine reliability implications of retiring plants in specific locations, meaning it does not inform the possibility of retiring any one specific plant and the potential transmission considerations such as Local RA requirements.^{xxiv} However, given the large amount of battery storage additions (11 GW to 15 GW), ample opportunity exists to solve local reliability constraints with new technology.

To compensate for reduced gas capacity, the model relies more heavily at certain times on economic imports, highlighting the particular importance of more effective regional coordination and other risk mitigation strategies for reducing reliance on in-state gas. This finding indicates potential to retire significant gas capacity in California by 2030, prioritizing the most impacted communities. The model also encounters no difficulty meeting intraday ramps caused by midday solar—the so-called “duck curve.”³³ This implies heavy investment in storage and demand shifting can manage these needs at relatively low risk and cost.

While the significant net reliability improvement in the technical report’s scenarios is mainly due to a system that combines everyday clean resources with parsimonious use of legacy gas resources, these modeled gas resources can also be a proxy for resources that should include cleaner alternatives. If they include more advanced forms of demand flexibility and prioritize building a more diverse portfolio of clean resources (including distributed energy resources and clean portfolios) that includes more “firm” clean resources, these alternatives might be cheaper than continued reliance on existing gas and help meet a very fast deployment schedule while maintaining a reliable grid. Relatedly, keeping legacy natural gas resources online but reducing their ability to collect energy market profits by decreasing annual generation could be expensive. Policymakers should articulate the specific services these legacy gas assets provide and stimulate

^{xxiv} As the technical report indicates, “Although our analysis and the California [environmental justice] assessment resulted in comparable magnitudes of gas generation, the chief difference between these analyses is location, with each method potentially retiring different amounts of capacity in each region. Our analysis did not include a nodal transmission topology of the California grid. Therefore, using CalEnviroScreen as the method to identify units for retirement would likely yield similar results to our analysis which used utilization-based metrics.” (Technical report, 52).

research and investment in zero-carbon technologies that could someday provide the same services at lower cost.

Following the model's procurement path offers no guarantees that the plants most harmful to human health will be retired first, that frequent start/stops won't create more local pollution, or that remaining plants won't choose to run more to serve the export market, particularly if the market expands as explored later in this report. While the model shows gas plants operating at lower capacity factors, without more granular understanding of transmission constraints and local grid needs it does not provide a robust prediction of gas plant stops and starts that would be a basis for air quality impact assessments.

Further, while most models consider the possibility of natural gas plant failures using a probabilistic approach that simplifies real world experience, they rarely consider the increased probability of failure or reduced output during extreme weather, running a plant hard for several days, or fuel supply issues. Using natural gas resources less often or less predictably may well exacerbate uncertainties around fuel supply, maintenance, and performance.

4.3 Policy recommendations – Planning for natural gas capacity retirements

In working to reduce the state's reliance on natural gas capacity and protect DACs from remaining plants' local pollution, California policymakers should focus on four categories of actions.

First, state energy planning institutions must create a joint, actionable plan to properly manage natural gas retirements that maximize reliability benefits while cutting pollution as quickly as possible, especially as they impact DACs. While the CPUC's IRP proceeding is rightly focused on reducing carbon emissions, it needs a more concerted focus on developing clean energy portfolios that replace natural gas plants in DACs. Specifically, the CPUC, in concert with CAISO and other stakeholders, should create a proceeding to inform the IRP with the explicit goal of planning a natural gas phase-out, using CalEnviroScreen to prioritize retirement order. The first steps of this plan should be to assess the feasibility of retiring all gas capacity in DACs by 2030 and to develop recommendations for doing so.

Second, the CPUC and CAISO should model their success with the Puente plant replacement by quantifying and sharing the Local RA value of natural gas power plants and encouraging LSEs to replace such plants with clean energy resource portfolios. Despite admirable progress toward clean energy procurement, there is no indication that today's IRP process will directly lead to natural gas retirements in DACs without changes, nor does any party responsible for procurement have the information needed to displace the most harmful power plants. Without a more holistic plant-by-plant examination, California's natural gas plants are likely to continue benefiting from this state agency game of hot potato.

The CPUC needs more sophisticated grid modeling tool inputs to its resource portfolio determinations to account for local reliability constraints. These tools allowing locational

consideration of natural gas retirements exist at CAISO and the CEC, and they need to be integrated at the outset of planning, so replacement resources can be identified to meet Local RA constraints and carbon goals. If confidentiality concerns restrict CAISO or agencies from sharing this information or acting on it in the IRP, the legislature should authorize necessary information sharing.

Third, the legislature and CEC should provide resources to DACs where natural gas plants are located to help them develop clean energy investment plans, capitalizing on new information and processes from the CPUC and CAISO in the prior recommendation. These plans should focus on creating economic opportunity, tax revenue, and job training opportunities through the energy transition in these communities. Such a plan needs to work within the market-based structures that govern most of the state’s grid and create proper incentives to maintain legacy assets while not giving these assets free rein to create subsidized exports.

Fourth, the CEC should commission a study to learn more about the specific local effects of greater instantaneous local pollution from more frequent natural gas plant cycling. State agencies have the modeling tools to simulate grid operations in a high-renewables future, and they must use those tools to prioritize greater understanding of local pollution impacts of higher gas cycling. Without greater transparency and outreach, environmental justice groups will continue to lack the tools needed to support utility-led plans for clean energy, and California risks a future where transitioning to clean energy exacerbates DAC air pollution.

Table 3. Policy recommendations to reduce dependence on natural gas capacity

Decision-maker	Policy
<p>Legislature, CPUC, CAISO, CEC</p>	<p>The CPUC, with input from CAISO and CEC, should create a proceeding to inform the IRP with the explicit goal of planning a natural gas phase-out, using CalEnviroScreen to prioritize retirement order. The first steps of this plan should be to assess the feasibility of retiring all gas capacity in DACs by 2030 and to develop recommendations for doing so. The outcome should be an enforceable plan to phase out and replace gas, updated regularly to reflect changes to the energy system and policy goals.</p>
<p>CPUC, CAISO, Legislature</p>	<p>Mirroring the successes in the Puente plant replacement, quantify and share the Local RA value of natural gas power plants serving Local RA needs. Where possible, encourage LSEs to coordinate and procure portfolios, possibly from the IRP, that can serve these needs. If confidentiality concerns restrict CAISO or agencies from sharing this information or acting on it in the IRP, the legislature should authorize necessary information sharing.</p>

CEC, Legislature	Provide resources to DACs where natural gas plants are located to develop clean energy investment plans focused on creating economic opportunity, tax revenue, and job training opportunities through the energy transition in those communities.
CEC	Commission a high-granularity study, accompanied by modeling, to determine risks to DACs from more frequent natural gas plant cycling under emissions reduction scenarios, including methane leakage and other safety issues along with the acute impacts of starting and stopping.

5. LEVERAGING DEMAND-SIDE RESOURCES

Demand-side considerations involve modifying how much and when electricity is used at different locations on the grid. Measures like energy efficiency, rooftop solar, and some forms of DR reduce the amount of electricity that must be delivered to end users from the bulk power grid, while measures like behind-the-meter battery energy storage systems and other forms of DR shift when electricity is used by an end user. All of these “behind the meter” interventions show up as changes to the electricity demand pattern, which affect the amount and type of supply-side resources needed to provide reliable electricity.

Among demand-side resources in the grid reliability policy context, DR usually takes center stage because it responds to operator directions or to high prices—that is, it can be called upon to actively manage tight grid conditions. The technical report specifically considered DR in its “Load Shift” mode, when it functions most like a battery by shifting when electricity is consumed. Not surprisingly, the analysis did not find much incremental advantage in adding Load Shift when already well provisioned with battery storage.

Two key insights stem from this finding. First, where DR is fungible with short-duration batteries, support for DR is an important policy to mitigate the risk of deploying batteries short of the needed but unprecedented rate, and it adds other co-benefits. Second, policymakers must prepare for the future opportunity of DR to match some of the reliability functions of the residual gas fleet.

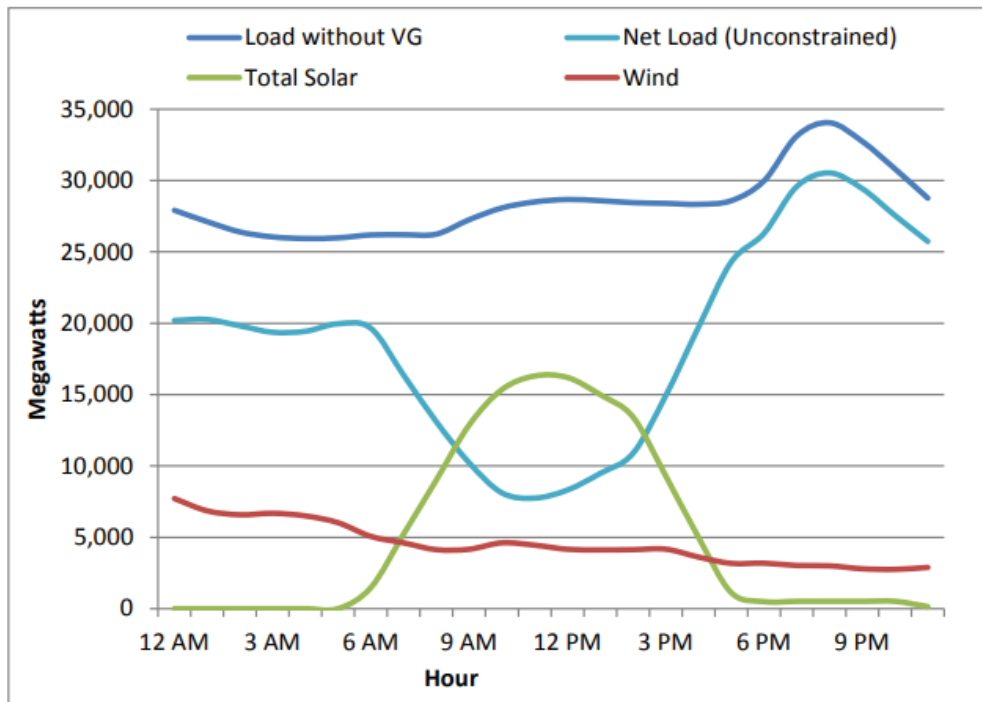
5.1 Background – The evolution of demand response in California

California has long mandated that utilities pursue all cost-effective energy efficiency and DR resources before procuring renewable energy and, if necessary, the lowest-emitting fossil fuel options.³⁴ In the past decade, the state has been highly successful in deploying energy efficiency measures, rooftop solar, and battery storage, in part supported by a mix of incentives, standards, and R&D programs. California has notably ranked in the top two of the American Council for an

Energy-Efficient Economy’s State Energy Efficiency Scorecard reports since their inception in 2006.³⁵

While the state led some important distributed energy resource studies and pilot programs in the 2010s, it made less progress in increasing the contribution of and driving high performance of these resources.³⁶ Recognizing the need for DR to play a larger role, the CPUC commissioned Lawrence Berkeley National Laboratory (LBNL) in 2015 to study DR’s potential contributions to California’s grid.³⁷

Figure 9. Illustrative net load “duck curve”



The figure shows load, solar, and wind profiles for California on March 29 in a scenario with 11 percent annual wind and 11 percent annual solar assuming no curtailment. “VG” refers to “variable generation,” or wind and solar. Source: National Renewable Energy Laboratory.³⁸

The LBNL studies highlighted vast amounts of untapped economic DR potential to help the state address its intraday “duck curve” problem—how growing shares of solar generation on California’s system increase the daily need for highly flexible resources to serve demand as the sun sets.³⁹ Specifically, DR can reduce the intraday ramping need by shifting load from the evening to the

afternoon (Load Shift) or by reducing evening demand outright (Load Shed).^{xxv} CAISO's recent success with Flex Alerts—which call for voluntary electricity conservation—also indicate that greater DR potential could be unlocked by giving customers opportunities to be compensated for these services.⁴⁰

However, early CAISO compensation methodologies comparing DR performance to a historical baseline resulted in underpayments to these resources, thus damaging their business case.⁴¹ Separately, the CPUC began its Demand Response Auction Mechanism (DRAM) pilot in 2016, which requires state IOUs to procure flexible DR from third-party aggregators of customer-sited resources (e.g., batteries, smart thermostats) in annual auctions.

After a 2019 CPUC staff evaluation identified performance, reliability, and bid competition issues, the commission extended the DRAM pilot through 2022 to test whether its adjustments would adequately address the program's shortcomings.⁴² However, California's leading DR aggregators argued that these changes stifled the growth of flexible DR,⁴³ and other stakeholder groups continue to call for an increased budget and role for DRAM.^{44,45}

Heat waves in August and September 2020 tested these DR resources' performance. While CAISO acknowledged their value in avoiding some instances of rotating outages,⁴⁶ its market monitor also laid out performance shortfalls and the challenges DR resources must overcome to meet their full potential.⁴⁷ These include misaligned financial incentives, slow DR ramping times, a lack of visibility into DR availability, and outdated methods for calculating DR performance.^{xxvi} Such challenges raise the important question of how California can grow its confidence in DR resources across all stakeholders, particularly as the state tries to ramp up their use to advance its climate and grid reliability goals.

In the midst of the heat waves, Governor Newsom directed CAISO, the CPUC, and the CEC to analyze the root cause of the resultant rotating outages, leading to a new rulemaking intended to apply those lessons to shore up near-term reliability. In March 2021, the CPUC issued a decision to improve DR capabilities ahead of the upcoming summer⁴⁸ by authorizing a paid media campaign to raise awareness of CAISO's voluntary Flex Alerts program and creating an Emergency Load Reduction Program (ELRP) pilot to compensate select non-residential customers for curtailing load

^{xxv} LBNL released three studies as part of this process; the technical report used outputs from the third, which forecast DR potential through 2030. Brian F. Gerke et al., "The California Demand Response Potential Study, Phase 3: Final Report on the Shift Resource through 2030," 2020, <https://doi.org/10.20357/B7MS40>.

^{xxvi} Specifically, these issues include that DR resources with RA contracts have misaligned incentives—for example, some DR resources must be available for dispatch (or else are penalized) but face little to no financial risk if they fail to deliver; CAISO could not access certain "slow-ramping" DR resources quickly enough, as they require relatively long lead times to become available for dispatch; CAISO could not see whether DR resources outside of the CPUC's jurisdiction were available for dispatch; outdated methods for calculating DR performance (i.e., comparing actual energy draw to some counterfactual benchmark) can lead to it being over-counted relative to actual performance; and a significant share of DR resources are not available on weekends and holidays.

in emergency conditions.^{xxvii} It also shored up utility DR programs, though some proceeding participants argued the decision largely excluded options to fix issues with and ramp up third-party DR aggregations.⁴⁹

In summer 2021, severe drought, heat, and wildfires led Governor Newsom to issue an emergency proclamation ordering the Joint Agencies and CAISO to further enhance grid reliability ahead of potential extreme weather in the summers of 2022 and 2023.⁵⁰ In December 2021, the CPUC issued a second series of decisions with more expansive demand-side measures.

One of these decisions expanded programs to reduce demand during tight system conditions. Namely, it extended the ELRP to residential customers and electric vehicle aggregations, doubled its compensation rate from \$1 per kilowatt-hour (kWh) to \$2/kWh, and directed the Flex Alert campaign to market the new residential ELRP to increase customer understanding, with special outreach to low-income households and customers in DACs.⁵¹

While ELRP performance is judged relative to a “simple” baseline, the decision orders IOUs to evaluate this methodology after the first program year, leaving room for improvement. The decision also funds installation of up to 300,000 smart thermostats in hot climate zones with the intent of expanding the number of resources capable of offering DR services, and directs IOUs to procure RA capacity from third-party DR providers.

Another decision funded a new Market Access program for the summers of 2022 and 2023 based on the Peak FLEXmarket platform—a partnership of community choice aggregator Marin Clean Energy and product developer Recurve that launched in June 2021.⁵² The program allows third-party aggregators to collect customers, enroll them in the FLEXmarket, and get paid for shedding or shifting demand.

These recent actions might finally put California on a path to capitalizing upon its growing demand-side resource base. The CPUC’s recent decisions largely involve rapidly developed pilot programs meant to address near-term needs, but they set the basis for improving, scaling, and permanently funding these initiatives. Today’s investments in bolstering DR may quickly compound, too—while the state’s need to swiftly electrify end uses across the building, transportation, and industry sectors will present new grid challenges, it will also bring new opportunities to expand programs to shift and shed flexible load and rely more on DR as a zero-carbon resource.

^{xxvii} ELRP events are rarer than Flex Alerts. “Prior to 2020, the CAISO issued a total of 20 Flex Alerts over a 10-year period. By comparison, the CAISO issued a total of eight grid emergency declarations [...] that would have triggered ELRP over the same period, if ELRP had existed in those earlier years.” “Emergency Load Reduction Program,” California Public Utilities Commission, accessed April 20, 2022, <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/emergency-load-reduction-program>.

5.2 Insight – Demand response as a risk mitigation strategy

The technical report looked narrowly at how increasing Load Shift would affect the California power grid’s dependability.^{xxviii} The study finds that due to ample battery capacity built by the model, extra Load Shift does not meaningfully improve reliability.^{xxix} This finding may seem to indicate the state should look elsewhere for demand-side measures to contribute to a clean, reliable grid. But the finding was likely more of a function of DR being a sensitivity examined on top of the battery-heavy portfolio. When viewed together with the much larger body of research into and evidence of demand-side measures’ efficacy, Load Shift and other kinds of DR are well worth pursuing.

Demand-side measures can substitute for supply-side resources and therefore contribute to resource diversity; their increased availability hedges against the risk of deploying new clean supply-side resources too slowly (including generators and storage). For example, the technical report finds that deploying Load Shift could reduce load by 1,500 MW in the early evening hours when solar output falls, hedging against battery deployment challenges such as supply chain disruptions.⁵³ Other measures like energy efficiency, rooftop solar, and Load Shed can also help temper load and peak demand growth to reduce the needed resource build-out rate or accelerate natural gas power plant retirements.

Demand-side measures also provide complementary reliability, resiliency, and public safety benefits to supply-side solutions or imports, as they lie closest to the affected load. While centralized generators provide the bulk of our power under most system conditions, they can be rendered less effective or useless under certain disaster conditions.

Load Shift is an important hedge against ambitious build rates for batteries, a potential cost-reducer,^{xxx} and a source of resource diversity, but other kinds of demand-side measures will likely have higher complementary resilience and reliability benefits in a highly decarbonized electricity system. Energy efficiency measures can help buildings retain their ambient conditions, reducing power draw while keeping residents safe from extreme temperatures. Distributed solar and battery storage can provide power to communities for critical services. Systems in place to encourage or pay people for reducing or shifting electricity demand—such as through the new residential ELRP

^{xxviii} The study isolated Load Shift in part because the product has shown significant potential in California-led studies but has not yet been deployed at scale; however, this report’s policy recommendations take a broader scope and apply to all types of demand-side measures.

^{xxix} The study did not re-run the RESOLVE model after introducing more Load Shift; if it had, it might have built less battery capacity to account for Load Shift’s similar value-add.

^{xxx} Grid-scale energy storage competes directly with Load Shift (which in turn can be provided by customer-side batteries) for a somewhat limited market. While a Load Shift market may cost-effectively displace some bulk energy storage, the latter could also provide a ceiling on the deployment of the former. Even if this situation plays out, it may still be wise to ensure the procurement of some Load Shift to take advantage of its complementary benefits (such as the ability to address local transmission challenges).

pilot—can provide sufficient relief to the power grid to avoid rotating outages or lessen their duration.

Demand-side measures will need to evolve as California moves toward 85 percent clean power and a fully decarbonized grid. The LBNL Demand Response Potential Study was completed when batteries were expensive and system planners were focused on managing the looming duck curve challenge. Battery prices have since plummeted, with the technical report finding it cost effective to rapidly build batteries to solve this problem while Load Shift plays a relatively small role in mitigating delayed deployment risk.

Nevertheless, the technical report also reveals that the residual 15 percent to 20 percent natural gas generation remaining on the state’s system shows up much more sporadically but with significant consecutive hours of operations, and this unpredictability suggests short-duration storage technologies might not be suitable to replace it. If California can boost the sophistication of its demand-side resources, they may be able to play a crucial role in replicating this value, helping further reduce natural gas generation and retire more power plants.

Yet using demand-side resources in this manner will require much greater confidence in the measurement, evaluation, and proper compensation of their performance. If stakeholders can’t agree on how much DR resources contributed and how much to pay them in more predictable events like the August and September 2020 heat waves, they may face greater challenges when trying to use such resources in more sporadic events that mimic these remaining uses of natural gas generators. Policymakers have a near-term opportunity to nail down verification and qualification of these resources during the kinds of relatively predictable events we experience now, before California needs to use them in even more challenging circumstances in the near future.

5.3 Policy recommendations – Demand-side resources to reduce reliability risk

In scaling up demand-side measures through the 2020s, California policymakers should focus on four categories of actions they can take.

First, CAISO and the CPUC must refine existing DR resource markets to ensure they deliver forecast load reductions^{xxx} when called upon and are appropriately compensated for their services—particularly since the size of these resources varies throughout the day and year. This should include following through on recommendations identified by CAISO’s Department of Market Monitoring in response to the August and September 2020 heatwaves.⁵⁴

Second, the CPUC should closely monitor and expand new programs established to address near-term reliability needs. Given the urgency of developing programs quickly enough to be ready for

^{xxx} The load forecast methodologies may also need to be improved to be more accurate.

the summers of 2022 and 2023, there will likely be room to improve aspects like measuring ELRP performance for appropriate compensation and grow programs like Market Access to reach more customers. Utility financial incentives to procure DR may be needed.

Third, DR resources can only grow in potential according to the technical readiness of appliances that can reasonably shed or shift load (e.g., water heaters) as well as the internet access to utilize them. State policymakers can expand California’s DR-ready stock by incentivizing development and deployment of these resources, such as through recent CPUC funding for smart thermostats. Policymakers should also extend reliable broadband service to communities that still lack it. Further, as California increasingly adopts electric vehicles to achieve Governor Newsom’s goal of 100 percent electric vehicle sales by 2035, the CPUC should continue advancing vehicle-grid integration capabilities—a DR resource that could deliver substantial value in the 2030s and 2040s as state vehicle stock turns over.^{xxxii}

Fourth, the CEC should study how to match demand-side resources with residual natural gas value. This requires analyzing and profiling the value natural gas power plants bring to an 85 percent clean electricity system in models, then characterizing how California’s growing stock of demand-side resources can replicate it with appropriate compensation.

Table 4. Policy recommendations to leverage demand-side resources

Decision-maker	Policy
CAISO, CPUC	Improve communications, forecasting, and baselining for DR resources to ensure the right level of both planning (i.e., for availability) and compensation.
CPUC	Set appropriate criteria for DR resources to qualify for RA, such as reasonable commitment costs and ramp rates; establish performance-based penalties and incentives for these resources to drive responsiveness.
CPUC	Seek ways to expand the market for DR, such as increasing utilities’ DRAM budgets and removing LSE-specific DR procurement caps.
CPUC	Monitor, revise, expand, and—if successful—permanently fund newly established DR pilot programs such as the ELRP and Market Access program, and consider utility performance incentives to drive greater procurement.

^{xxxii} A summary of the Commission’s vehicle-grid integration activities can be found here: “Vehicle-Grid Integration Activities,” California Public Utilities Commission, accessed April 20, 2022, <https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/transportation-electrification/vehicle-grid-integration-activities>.

CEC	Accelerate efforts to leverage demand-side flexibility through innovative codes and standards, and continue to work closely with other agencies to streamline demand-side programs.
Legislature, CPUC	Expand funding for development and deployment of smart appliances as well as for increasing broadband access, particularly in DACs. Continue efforts to advance vehicle-grid integration capabilities.
CEC	Study how to match demand-side resources with the residual value that natural gas resources provide in an 85 percent clean electricity system.

6. IMPROVING REGIONAL COORDINATION

Regional coordination involves improving the ease and transparency of intra- and inter-state energy trading. Energy trading provides economic value by allowing the lowest-cost resources access to a broader regional footprint and reliability value by allowing extra resources to be shared across sub-regions. These benefits have driven the gradual progress of regional coordination across the West, summarized below along with some of the benefits to date.

As California transitions to a clean energy grid, opportunistic “economic imports” (i.e., imports not tied to dedicated contracts for delivery) are one of the main head-to-head competitors with in-state legacy gas resources for ensuring reliability on an hour-by-hour basis. Sensitivities in the technical analysis show that economic imports remain available even as other states move along their own paths to decarbonizing their electricity sectors by, for example, retiring their coal plants in favor of new renewables and storage. The study also shows high operating reserve margins across the rest of the West when California is drawing on economic imports to support its grid, suggesting imports will be available when needed.

In this context, better regional coordination is critical to achieving decarbonization goals, notwithstanding the potential lifeline it might offer to some dirtier resources in the near term. Furthermore, as the deployment of energy-limited resources like batteries continues apace, better regional coordination will be important for ensuring energy adequacy by arranging transfers between sub-regions outside of critical windows when transmission and peak generating resources are at their limits.

6.1 Background – The gradual progress of regional coordination in the West

In the West, only California has an organized power market, through which the state’s three largest utilities pool their transmission assets and competitive generation to balance supply and demand

across their combined territory. CAISO is an independent entity operating a market through which least-cost resources are selected to serve electricity demand in any given period.

At a December 2021 Western Governors' Association meeting, Commissioner Richard Glick of the Federal Energy Regulatory Commission pressed states to form a regional power market beyond the single-state CAISO, noting he was "very concerned about the next couple years if we don't figure out a better way to coordinate the region's efforts."⁵⁵ As climate change worsens the severity and frequency of grid-threatening droughts, heat waves, and wildfires, and as the West adopts more weather-dependent renewable and energy storage resources, states could benefit immensely from greater intra- and interstate coordination.

California's state legislature has considered several times whether to expand CAISO beyond its home state, with the latest effort falling through in September 2018.⁵⁶ Supporters argue it would benefit from being able to schedule and deliver excess renewable energy to other states, more easily source complementary clean energy from a broader area, better coordinate development of new transmission lines, reduce operational costs, and put pressure on fossil fuel power plants unable to survive in a competitive marketplace with near-zero marginal cost renewables.

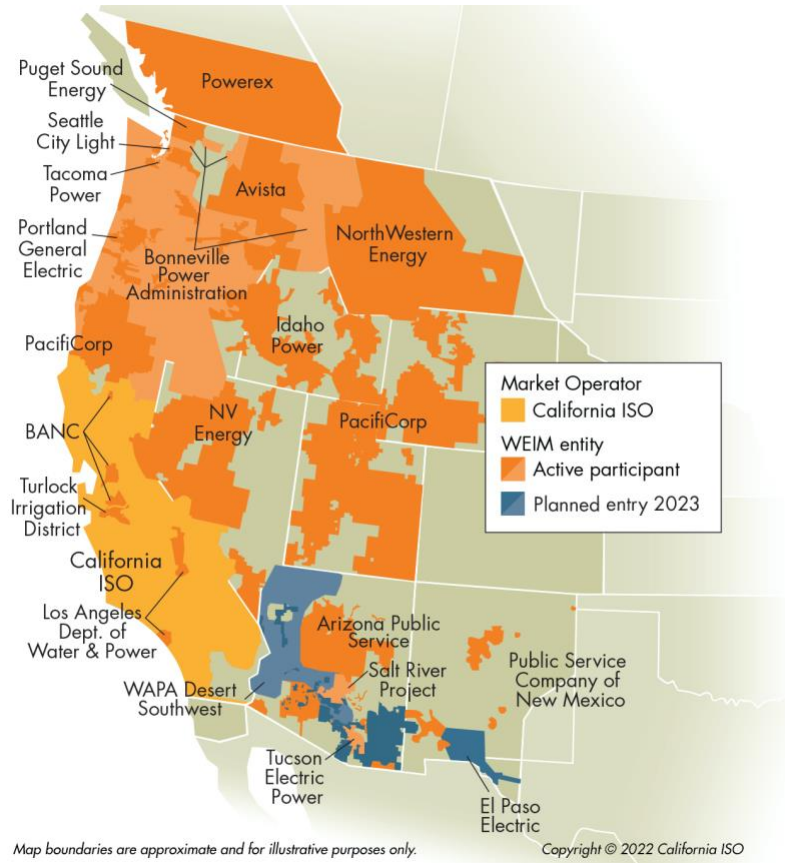
On the other hand, those opposed to expansion are concerned about California giving up its autonomy over CAISO's wholesale market and transmission rules,⁵⁷ ceding control of the state's ability to pursue its own clean energy goals,^{xxxiii,58} and inadvertently supporting both out-of-state^{xxxiv,59} and in-state^{xxxv,60} fossil fuel generators—all of which could harm climate and local environmental justice efforts if realized. A Next 10 report summarizes this regionalization debate in much more detail.⁶¹

^{xxxiii} A CAISO study finds that "a regional marketplace will not affect individual states' procurement policies. A regional grid wouldn't allow federal regulators to exercise authority at the expense of state authority. Federal authority over all interstate transmission grids is already regulated by FERC, and wholesale electricity transactions are considered interstate commerce." "A Regional Energy Market - Overview" (California Independent System Operator, July 8, 2016), <http://www.aiso.com/Documents/SB350Study-OverviewImpacts-RegionalEnergyMarket-FastFacts.pdf>.

^{xxxiv} For example, depending on the market design, a West-wide RTO could lead fossil fuel generators in states without clean electricity or carbon pricing policies to run more often, whether by holding a competitive advantage over states with carbon pricing ("emissions leakage") or serving more in-state load while shipping clean electricity elsewhere ("resource shuffling").

^{xxxv} An expanded RTO opens the possibility of a subset of California's natural gas power plants operating more frequently to balance other states' renewables or outcompete their remaining coal-fired generation, leaving California DACs to suffer more local air pollution while the broader grid decarbonizes. A CAISO study found that regionalization "decreases the emissions of NO_x, PM_{2.5}, and SO₂ from power plants statewide and in the air basins of greatest concern for DACs, depending on the dispatch of the fleet of natural gas-fired power plants," but given several of its model's limitations, much more study is needed to ensure DACs benefit from an expanded RTO.

Figure 10. Western Energy Imbalance Market



Source: Western Energy Imbalance Market.

In place of establishing a broader RTO, CAISO has worked with Western utilities to enhance regional coordination through its energy imbalance market (EIM). The EIM allows all member utilities to source or unload excess energy as needed via a “real-time” market, accruing savings of \$323 million to California ratepayers⁶² and cutting 105,413 metric tons of carbon dioxide across the West (equivalent to taking 22,713 cars off the road for one year) in 2021.^{xxxvi}

^{xxxvi} GHG reductions are attributed to the improved integration of renewable resources, allowing more renewable energy to displace fossil fuel generation rather than be curtailed. EIM emissions reduction estimates apply a default emissions rate of 0.428 metric tons CO₂/MWh to the avoided renewable energy curtailment estimate; however, the amounts by which each individual fossil fuel power plant across the Western Electricity Coordinating Council reduced its generation (each with its own specific emissions rate) cannot be precisely known. “Western EIM Benefits Report - Fourth Quarter

As a next step, CAISO has been working with EIM members on an Extended Day-Ahead Market (EDAM) initiative, which would build on its EIM by adding day-ahead operations. EDAM does not quite rise to the coordination level of an RTO, which requires utilities to give control of their transmission assets and some planning functions to an independent market operator. But it would still bring great benefits to all participants by adding another layer of planning and visibility to energy transactions among LSEs.⁶³

Regionalization is also progressing throughout the West independent of California’s action, meaning the state could lose influence over regional market development. A regional power market largely based in the Great Plains (the Southwest Power Pool) extended RA services to support the Western Resource Adequacy Program and established an EIM-like Western Energy Imbalance Service (WEIS) market to different utilities in the Interior West.⁶⁴ Colorado⁶⁵ and Nevada⁶⁶ passed laws requiring their utilities to join organized wholesale markets by 2030, and a recent Oregon law⁶⁷ requires the state’s Department of Energy to study the benefits of joining an RTO. A group of 11 power providers led by Xcel Energy is also exploring regional market opportunities.⁶⁸ If EIM members decide to join other RTOs, significant benefits of CAISO expansion could be left on the table.

A recent state-led, U.S. Department of Energy-funded study sheds light on the ratepayer savings different levels of regional coordination could unlock.⁶⁹ By 2030, extending day-ahead market services to the EIM and WEIS—like what CAISO is working toward with its EDAM initiative—could save California ratepayers \$153 million annually by 2030, *in addition* to savings achieved with only the EIM and WEIS real-time market products.^{xxxvii} Establishing a single West-wide RTO could save California ratepayers \$478 million annually by 2030 over the EIM’s real-time services—and save all Western ratepayers nearly \$2 billion.^{xxxviii}

However, a scenario in which the rest of the West forms an RTO that excludes CAISO would bring lower savings, to the tune of \$315 million annually by 2030 for California and \$1.4 billion for the West. Given the pace at which states across the West are exploring opportunities to form or join regional markets, it’s worth reopening past debates to consider how circumstances have changed

2021” (Western Energy Imbalance Market, January 31, 2022), 21–22, <https://www.westerneim.com/Documents/ISO-EIM-Benefits-Report-Q4-2021.pdf>.

^{xxxvii} In all study scenarios, including the baseline scenario that analyzes the EIM and WEIS with only real-time market products, the model assumes that by 2030, all Western balancing authorities join one or the other (mostly the EIM). Savings do not net out operating costs from running day-ahead market services or one or more RTOs given the wide range of estimates, but the study reports these as ranging roughly from 10 percent to 50 percent of savings.

^{xxxviii} An older study from 2016 found much higher annual California ratepayer net savings of \$1.5 billion by 2030, with these benefits stemming from “(1) savings from reduced capital investments for RPS-related procurement; (2) reduced production, purchase, and sales costs for wholesale electricity; (3) reduced capital investments from regional load diversification; and (4) reduced grid management charges for system and market operations.” “Senate Bill 350 Study - The Impacts of a Regional ISO-Operated Power Market on California - Executive Summary” (California Independent System Operator, July 8, 2016), 1–ix, <http://www.caiso.com/Documents/ExecutiveSummary-SB350Study.pdf>.

since 2018 and decide whether the risks of forming a West-wide RTO are worth taking to capture the higher associated ratepayer savings.

California LSEs also lean on imports to maintain RA, but import RA resources do not face the same requirements as in-state resources, creating potential performance issues. Import RA contract rules have historically required that an energy provider submit energy bids at a specific connecting point into CAISO's system in its day-ahead market—not that they be tied to specific generators. This has left the door open for some RA requirements to be met by speculative supply—power which is also committed to serve RA needs in other states and which therefore might not be available to CAISO when called upon.⁷⁰

In recent years, the CPUC has worked to find the right balance of import RA restrictions: lenient enough to allow for a robust use of imported energy but strict enough to ensure all such resources are dependable. In June 2020, the CPUC adopted new RA import requirements aimed at addressing speculative supply concerns.⁷¹ In April 2021, CAISO proposed additional requirements, including limiting RA contracts to resource-specific imports that can meet certain firm transmission and attestation requirements.⁷² In June 2021, the CPUC declined CAISO's proposal, opting for more time to review the effectiveness of the less stringent import RA rules adopted a year earlier.⁷³

6.2 Insight – The increased value of regional coordination in a clean energy system

Energy imports (as distinct from RA contracts) can be loosely categorized into “dedicated” and “economic” buckets.^{xxxix} Dedicated imports are out-of-state resources that have contracted with California utilities to deliver energy, such as hydropower from the Pacific Northwest. Economic imports are out-of-state resources that lack contracts with in-state utilities but may send energy into the state when profitable to do so. While dedicated imports are generally reliable (assuming no transmission line disruptions),^{xl} depending on economic imports to balance supply and demand can be risky, as California may find itself seeking to draw power from a resource base tied up serving other states' local demand.

The technical report highlights the close connection between in-state natural gas resources and economic imports. While wind, solar, batteries, geothermal, and hydropower generators operate at very low cost once built, there often is not enough such energy available (including from dedicated imports) in certain hours to fully meet demand in California under a system designed to

^{xxxix} Imports for energy differ from imports for RA, the latter of which are categorized as “resource specific” or “non-resource specific” (which may in turn include speculative supply).

^{xl} For example, in July 2021, the Bootleg Fire in Oregon affected several transmission lines that together reduced imports to California by about 5,500 MW. Sonal Patel, “California Braces for New Reliability Crisis as Wildfire Threatens Crucial Intertie,” *POWER Magazine*, July 12, 2021, <https://www.powermag.com/california-braces-for-new-reliability-crisis-as-wildfire-threatens-crucial-intertie/>.

only meet 85 percent of the state’s load with zero-carbon resources. The difference is made up by two other sources: in-state natural gas generators and economic imports, with the proportion of each that serves load in a given interval being sensitive to natural gas price assumptions.

The technical report characterizes combined dependence on in-state gas and economic imports as a reliability risk when net load—that is, after accounting for clean electricity and dedicated imports—exceeds the energy that can be provided by in-state gas capacity alone. In hours where this margin is exceeded, California is dependent on some economic imports to match supply and demand, creating some risk that extreme weather conditions could significantly reduce their availability.^{xli}

Some reliance on economic imports is essential to low-cost, reliable electricity service because economic imports contribute to resource diversity, reduce costs, and bring complementary system balancing and resiliency benefits. Greater regional coordination also has important implications for the operations of in-state natural gas power plants and the energy adequacy of the West’s growing stock of batteries.

Similar to demand-side measures, imports (economic and dedicated) can substitute for in-state supply-side resources and therefore contribute to resource diversity. The ability to bring in power from other states hedges against the risk of failing to deploy new clean in-state supply-side resources quickly enough, and can facilitate faster West-wide fossil fuel power plant retirements. Imports can also reduce the amount of land California needs to dedicate to power generation to meet its clean electricity goals—a nontrivial benefit given the state’s challenging permitting environment. Perhaps most importantly, California might need to count on some economic imports, as a few of the most-stressed future system conditions tested in the technical report show some reliance on them.

Economic imports are also cheaper than building more in-state resources, running in-state natural gas-fired generators more frequently, or contracting for more dedicated imports. For example, economic imports may derive from otherwise curtailed renewable energy or more economic power plants shipping excess energy to California. The EIM already shows this potential.

Greater regional coordination brings complementary system balancing benefits that are generally more expensive to provide through in-state supply- and demand-side measures alone. Variable energy resource production becomes less correlated when spread over a large enough area, transforming local energy shortages into regional opportunities.⁷⁴ Texas’ Winter Storm Uri showed

^{xli} For example, in August and September 2020, an extreme heat wave affected most of the West, “drastically” reducing net imports into California. In an integrated West-wide RTO where bidding behavior and RA obligations become transparent, the risk of these imports failing to perform as projected becomes knowable, allowing the ISO to plan accordingly. “Root Cause Analysis - Mid-August 2020 Extreme Heat Wave” (California Energy Commission; California Independent System Operator; California Public Utilities Commission, January 13, 2021), 22, <http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf>.

that regional coordination also has resilience benefits during extreme weather events.⁷⁵ As California—and the rest of the West—accelerate wind and solar adoption, regional coordination to facilitate this trading will become increasingly beneficial.^{xlii}

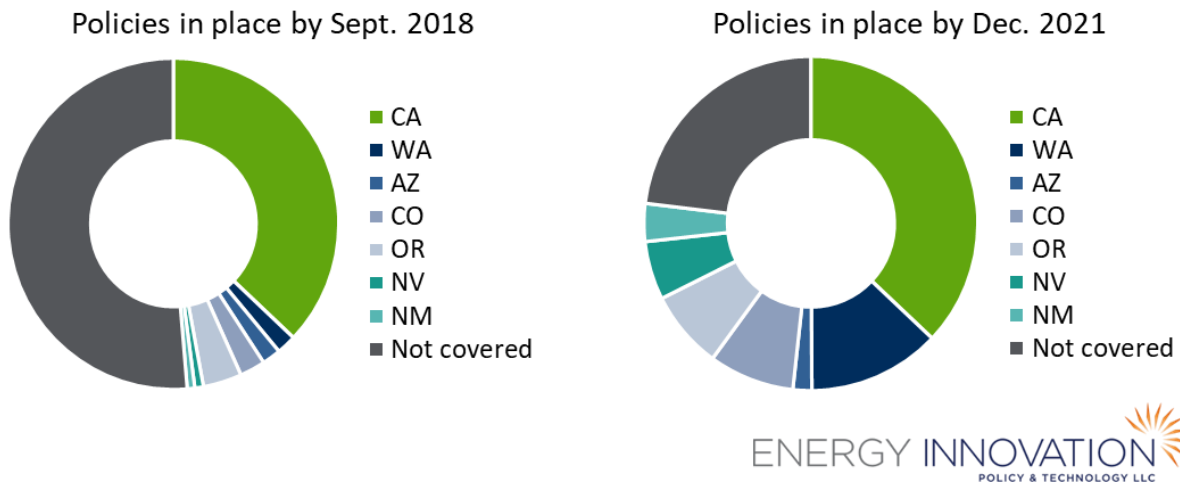
Without proper advance planning, greater regional coordination risks local tradeoffs with important implications for DACs. While studies show a West-wide RTO would reduce regional power system costs and GHG emissions, it may also increase operations from certain natural gas-fired power plants helping to integrate more renewable energy or replace lost coal-fired generation elsewhere. If California’s natural gas power plants run more often to balance supply and demand throughout the rest of the West, its DACs may experience higher levels of local air pollution while other states’ air quality improves. California—and other states considering entering a regional market—will need to weigh these potential tradeoffs and identify ways to mitigate them, such as by pairing market expansion efforts with a parallel plan for retiring in-state natural gas.

Finally, growing shares of renewable energy and battery storage across the West make energy adequacy a more important concept. Managing reliability becomes less of an hourly capacity challenge (associated with meeting peak and ramping resources up or down) and more of a daily energy challenge, where batteries need to be sufficiently charged earlier in the day to be available later in the evening. As the clean energy transition progresses, visibility into the rest of the West’s operations will be increasingly valuable to know what will or won’t be needed or available throughout the day, as well as to take advantage of shifting energy between regions when transmission flows would otherwise be low.

The technical report shows that partial reliance on economic imports is resilient to different conditions, such as a more complete clean energy transition throughout the West, limitations on economic imports, and 11.5 GW of in-state natural gas retirements. For example, the technical report shows that if the West retired all coal by 2030 and replaced that energy with wind, solar, and batteries, California could still serve load dependably. This is quickly becoming a reality: The share of Western states’ 2020 electricity sales covered by a state clean electricity policy rose from 49 percent in September 2018 (when California passed SB 100) to 77 percent at the end of 2021—with the actual clean electricity share higher when including existing clean electricity and utility goals in non-covered states such as hydro-rich Montana.

^{xlii} A U.S. Department of Energy-funded study led by representatives from all 11 Western states found that an RTO would best facilitate the increased use of clean energy technologies throughout the region, while also best supporting the “reliable, affordable provision of energy to consumers.” “New DOE Report Shows How Continued Western State Collaboration Can Support Affordable, Reliable, Clean Energy” (U.S. Department of Energy, September 20, 2021), <https://www.energy.gov/eere/articles/new-doe-report-shows-how-continued-western-state-collaboration-can-support-affordable>.

Figure 11. Share of Western states’ 2020 electricity sales covered by state clean electricity policies



This figure applies future clean electricity targets to 2020 electricity sales (based on Energy Information Administration data) to demonstrate the growth in legislative commitments since 2018. It does not include utility commitments or the current share of clean electricity achieved in the “not covered” states (Utah, Idaho, Montana, Wyoming).

However, the technical report did not examine every scenario—only greater regional coordination can allow California and its neighbors to confidently rely on one another through the transition. A West-wide RTO may be the most efficient way to achieve this, though the incremental approach of expanding utility membership and the scope of services provided by the EIM can help build confidence for even greater integration.

6.3 Policy recommendations – Maximizing the benefits of regional coordination

In working to improve regional coordination throughout the West, California policymakers should focus on four categories of actions they can take.

First, the state should re-examine expanding CAISO within California^{xliii} and across the Western Electricity Coordinating Council (WECC), as an RTO provides the most efficient means of balancing supply and demand over a region—particularly as the West’s share of renewable energy rises. The last time California legislators considered expanding CAISO (in September 2018), the state was largely in a class of its own in committing to decarbonize its power sector.

But much has changed since then. Policymakers in Colorado, Nevada, New Mexico, and Washington have all greatly increased their states’ clean electricity ambitions, reducing but not

^{xliii} Such as by considering integrating publicly owned utilities like the Los Angeles Department of Water and Power.

entirely eliminating the risk of an expanded CAISO inadvertently propping up coal-fired assets in other states. Wind, solar, and battery storage technologies have also continued to plummet in cost, further undercutting fossil fuel competitiveness and opening the door to greater market entry for these resources. Thus, California is both in a better position than in 2018 to expand into a region now set to be overflowing with renewable energy and at risk of losing a fleeting opportunity to craft the rules and leverage the benefits of a single Western market.

On the other hand, expanding CAISO into other states carries real concerns around governance, emissions leakage, resource shuffling, and environmental justice. A West-wide RTO would see all states share control rather than be responsive or deferential only to California policy (although California would still have authority over its own resource procurement). Thus, any legislation should include protection on these issues, such as working with states to design a regional market that is sufficiently flexible to accommodate states' unique policy priorities, and coupling expansion with other actions to phase out natural gas facilities more quickly in California's DACs.

The West will eventually reach a tipping point where much more renewable energy is on its system, and the benefits of balancing it over a much larger region will clearly outweigh the risks of supporting the little remaining fossil generation. Given the recent advancement of Western states' clean electricity policies and the long lead time needed to design a West-wide RTO framework acceptable to all parties, it's worth revisiting these issues now.

Second, in the absence of CAISO expanding beyond California (or in parallel until such an expansion is realized), the state should pursue all opportunities to improve regional coordination. For example, CAISO should continue work on its EDAM initiative. While well on its way, California and other EDAM stakeholders still must contend with how to share governance over its market product as well as how to manage the cost allocation of paying for access to utilities' transmission lines.⁷⁶

Third, California should seek to understand how uncontracted import availability may change as the Western grid decarbonizes. An improved understanding of this paradigm can help ensure the state builds out the right mix of supply-side resources and demand-side measures to withstand low-import periods while minimizing its reliance on its natural gas facilities. This kind of regional resource planning would be a more natural outcome of a West-wide RTO, but it could be done multilaterally.

Fourth, the CPUC should continue to closely monitor import accounting for RA purposes after passing on CAISO's proposal for additional requirements to minimize speculative supply risks. Striking the appropriate balance is essential to allowing California utilities to contract with cheaper out-of-state options for RA while ensuring these resources actually deliver energy when called upon.

Table 5. Policy recommendations to improve regional coordination

Decision-maker	Policy
Legislature, Governor	Re-examine expanding CAISO across the WECC. Reopen dialogue with other states around governance of a regional RTO and shared environmental and economic policy objectives. Increase DAC inclusive participation to protect against the potential for increased local air pollution in these communities.
CAISO	Keep up the momentum on EDAM and explore other opportunities to expand EIM services and coordination.
CEC	Commission studies to understand the conditions in which California could benefit from imports vs. those conditions that affect all of WECC such that it would be too risky to rely on imports, particularly as state resource mixes evolve across the West.
CPUC	Monitor import RA contracts to ensure they are delivering energy when called upon. Revisit CAISO’s proposal for more stringent requirements if the CPUC deems the risk of speculative supply still too high after testing the new rules adopted in June 2020.

7. CONCLUSION

Policymakers have an opportunity to push California’s clean energy transition even faster, bringing 2030 climate goals within reach. The implications are huge for California residents but may be just as big for the rest of the world. Other states and countries look to California’s progress to set and grow confidence in their own ambitions. Achieving an 85 percent carbon-free grid by 2030 in the world’s fifth largest economy would prove to the rest of the U.S. and the world that renewables can be the backbone of a reliable, affordable electricity system.

The technical report shows the value of consistent focus on resource diversity, including the particular value of offshore wind and geothermal in mitigating risks of under-procurement and RA. It also shows the potential to retire natural gas power plants, focusing first on DACs. But policymakers will have to reform planning, siting, transmission, and procurement policies to achieve this potential. In particular, an interagency strategy to retire gas appears to be urgently needed.

Resource diversity can come in forms other than in-state power plants—demand-side and regional solutions are additional sources of risk mitigation. Load Shift can help mitigate the need for and potential supply chain risks associated with storage. Policymakers should also focus on evolving demand-side measures to fill the role of dispatchable natural gas power plants in a high-renewables future.

Because dependence on neighbors is an important source of diversity, California must continue to focus on improving coordination through the EIM. Policymakers should reconsider the prudence of expanding CAISO to a West-wide RTO in light of neighbor-state pledges to substantially decarbonize their grids and join regional markets, while limiting the ability of expanded markets to increase in-state gas generation.

Together, these policy measures can help California navigate a rapid and equitable clean energy transition with confidence in ensuring grid reliability.

APPENDIX – SUMMARY OF POLICY RECOMMENDATIONS

Decision-maker	Policy – Accelerating and diversifying clean energy deployment
CPUC	<p>Within the IRP, actively help guide the “right” mix of clean supply-side resources:</p> <ul style="list-style-type: none"> ● Continue and expand on the work of the Joint Agencies, CAISO, and GO-Biz to address procurement barriers through tracking, identifying, and resolving issues with individual projects that are critical for transitioning to a clean and equitable energy future. ● Incentivize more diverse supply (like offshore wind and geothermal) and more demand-side resources, focusing on the IRP proceedings. ● Err on the side of over-procurement, in part by embracing bullish forecasts of vehicle and building electrification.

CAISO, CEC, CPUC	<p>Work to improve the IRP process:</p> <ul style="list-style-type: none"> ● Incorporate reliability modeling methods like those used in the technical analysis that retain enough hourly information in multiple weather years to help assess cost and reliability implications of many possible variations in procurement orders, to gain intuition of how these might perform under certain stress cases. ● Use 8,760-hour reliability models, across many weather years, like the ones used in the technical analysis, to evaluate the aggregate system RA procurement, especially against periods of possible stress. ● Work with the research community and other stakeholders to develop new methodologies to create a more dynamic approach to the RA accreditation, evaluation, and settlement system. This should include work on energy sufficiency given the rise of use-limited resources like batteries. ● Work with the research community and other stakeholders to develop a better characterization of system risk from reliance on economic imports and create related representative stress scenarios to include in the multiple runs of simpler reliability models. ● Seek to better incorporate climate trends into the data, including their impact on transmission risk posed by wildfires, low or extreme hydropower conditions, and extreme regional loads during heatwaves.
CPUC, Utilities, CAISO	<p>Coordinate with the CAISO transmission planning process to increase transmission and develop more least-regrets solutions that can meet the needs of multiple deployment scenarios.</p>
CAISO	<p>Reform the interconnection queue process to prioritize valuable locational attributes of proposed projects.</p>

Decision-maker	Policy – Reducing dependence on natural gas capacity
Legislature, CPUC, CAISO, CEC	The CPUC, with input from CAISO and CEC, should create a proceeding to inform the IRP with the explicit goal of planning a natural gas phase-out, using CalEnviroScreen to prioritize retirement order. The first steps of this plan should be to assess the feasibility of retiring all gas capacity in DACs by 2030 and to develop recommendations for doing so. The outcome should be an enforceable plan to phase out and replace gas, updated regularly to reflect changes to the energy system and policy goals.
CPUC, CAISO, Legislature	Mirroring the successes in the Puente plant replacement, quantify and share the Local RA value of natural gas power plants serving Local RA needs. Where possible, encourage LSEs to coordinate and procure portfolios, possibly from the IRP, that can serve these needs. If confidentiality concerns restrict CAISO or agencies from sharing this information or acting on it in the IRP, the legislature should authorize necessary information sharing.
CEC, Legislature	Provide resources to DACs where natural gas plants are located to develop clean energy investment plans focused on creating economic opportunity, tax revenue, and job training opportunities through the energy transition in those communities.
CEC	Commission a high-granularity study, accompanied by modeling, to determine risks to DACs from more frequent natural gas plant cycling under emissions reduction scenarios, including methane leakage and other safety issues along with the acute impacts of starting and stopping.
Decision-maker	Policy – Leveraging demand-side resources
CAISO, CPUC	Improve communications, forecasting, and baselining for DR resources to ensure the right level of both planning (i.e., for availability) and compensation.
CPUC	Set appropriate criteria for DR resources to qualify for RA, such as reasonable commitment costs and ramp rates; establish performance-based penalties and incentives for these resources to drive responsiveness.
CPUC	Seek ways to expand the market for DR, such as increasing utilities' DRAM budgets and removing LSE-specific DR procurement caps.

CPUC	Monitor, revise, expand, and—if successful—permanently fund newly established DR pilot programs such as the ELRP and Market Access program, and consider utility performance incentives to drive greater procurement.
CEC	Accelerate efforts to leverage demand-side flexibility through innovative codes and standards, and continue to work closely with other agencies to streamline demand-side programs.
Legislature, CPUC	Expand funding for development and deployment of smart appliances as well as for increasing broadband access, particularly in DACs. Continue efforts to advance vehicle-grid integration capabilities.
CEC	Study how to match demand-side resources with the residual value that natural gas resources provide in an 85 percent clean electricity system.
Decision-maker	Policy – Improving regional coordination
Legislature, Governor	Re-examine expanding CAISO across the WECC. Reopen dialogue with other states around governance of a regional RTO and shared environmental and economic policy objectives. Increase DAC inclusive participation to protect against the potential for increased local air pollution in these communities.
CAISO	Keep up the momentum on EDAM and explore other opportunities to expand EIM services and coordination.
CEC	Commission studies to understand the conditions in which California could benefit from imports vs. those conditions that affect all of WECC such that it would be too risky to rely on imports, particularly as state resource mixes evolve across the West.
CPUC	Monitor import RA contracts to ensure they are delivering energy when called upon. Revisit CAISO’s proposal for more stringent requirements if the CPUC deems the risk of speculative supply still too high after testing the new rules adopted in June 2020.

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