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Envisioning the California Grid for the Future: Clean, Affordable, Reliable, Resilient, Equitable, and Safe

Analysis and Recommendations

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the climate center

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The Climate Center Policy Guidance Document

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Executive Summary

This paper presents a pathway for reforms needed in California to achieve a future in which everyone has access to clean, affordable, and reliable electricity. The landscape in this new world is dotted with solar panels on every suitable rooftop, complemented by a resilient network of microgrids as well as mobile and stationary batteries that seamlessly balance energy supply and demand. Clean air is widespread as fossil fuel generation no longer pollutes. The proposed reforms are driven by strong economic, moral, and practical reasons that highlight the need for immediate action:

- California faces an electricity affordability[1] crisis, with rates soaring far beyond national averages and contributing to financial distress for many households.
- The dual pressures of increasing electricity demand and climate change — combined with skewed utility incentives toward capital-intensive infrastructure — are driving up costs.
- Environmental injustice persists. Polluting, fossil-fueled power plants disproportionately harm lower-income communities of color, while local, clean energy solutions are out of reach for these communities due to regulatory and financial constraints.
- State policies and planning practices continue to suppress Distributed Energy Resources (DERs),[2] including local-scale solar, mobile and stationary battery storage, and microgrids.

The integration of DERs into California's electrical grid will reshape our energy ecosystem, transforming our one-way system of power flowing from the grid to users into a flexible, bidirectional system capable of both supplying and saving electricity. To fully harness the benefits of this technology revolution, California must:

- Dismantle regulatory roadblocks;
- Reform grid planning and architecture;
- Enable an open-access distribution network where electricity is bought and sold;[3]
- Acknowledge and compensate the full value of DERs; and
- Reform the ways in which utilities are compensated to incentivize least cost alternatives and better align with state climate goals for reliability, resilience, and equity.

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[1] https://californiaglobe.com/fl/report-from-cpuc-public-advocate-finds-residential-electricity-prices-more-than-2x-the-national-average/

[2] Distributed energy resources (DERs) are small-scale energy resources that generate, store, or consume energy, often near where electricity is used.

[3] https://energy.ucdavis.edu/energy-bites-seminar-may-9th-2024/

This new energy ecosystem will usher in an era of clean, affordable, reliable, and resilient energy, accelerating the achievement of California's clean energy goals. It will demonstrate to the nation and the world what is possible. The Grid for the Future isn't a far-fetched dream, but an attainable reality with existing technologies if policymakers act with ambition and determination.

> **"The secret of change is to focus all of your energy not on fighting the old, but on building the new." – Socrates**

Introduction

California stands on the threshold of a transformative era in electricity production and consumption. Electricity prices could decline as the state transitions to clean, non-polluting power sources, supplanting outdated fossil fuel plants. This restructured electricity system promises consumers unprecedented flexibility and adaptability, delivering affordable, resilient, and clean energy to customers worldwide.

This emerging paradigm, which The Climate Center calls the Grid for the Future, empowers individuals and communities to take control of their energy bills through active management of both electricity production and consumption. This shift heralds a new era in energy deployment, reliability, and sustainability, fundamentally altering power supply and usage from a utility-controlled, top-down model to a grid-supported, bottom-up approach.

This paper outlines a pathway for achieving this vision of a consumer-centric energy portfolio that is decentralized and resilient. The current, centralized bulk power system — with its rigid rules and incentives — constrains energy options and outcomes. These limitations leave California ill-equipped to navigate the seismic forces reshaping the economic, technological, and societal energy landscape.

As California's decision-makers confront this transition, several questions emerge. How quickly will this future materialize? Can the state ensure an equitable unfolding of this new energy paradigm? Is it possible to achieve this vision before significant investments are made in potentially underperforming or stranded assets in California?

The Challenges Driving Changes in California's Energy System

The evolving energy landscape is facing multiple challenges: high growth in energy demand as California moves to electrify everything, the affordability of electricity, the need for climate resiliency, and legislation requiring the transition to low-carbon energy sources. As energy needs increase, public pressure mounts to provide reliable electricity at a reasonable cost while reducing environmental impacts.

The traditional, centralized grid model is increasingly ill-equipped to meet the demands of a rapidly evolving energy landscape. The conventional power grid is designed for one-way electricity flow from large, centralized power plants to end users, which makes the system vulnerable to more extreme events and less reliable and resilient. In this current system, regulatory barriers prevent the commercial viability of bidirectional power trading, hindering distributed energy resources (DERs) from solving the needs of affordability, resilience, equitable access, and reliability.

The Affordability Crisis

California's electricity sector is grappling with an unprecedented affordability crisis. Rates have skyrocketed well beyond national averages, placing a significant financial burden on residents across the state. Recent rate hikes have pushed many Californians to the brink of financial distress. One in five households is behind on electricity bills,[4] one in three low-income households is struggling to pay, [5] and the average electricity debt per customer reached $747 in July 2023.[6]

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[4]https://californiaglobe.com/fl/report-from-cpuc-public-advocate-finds-residential-electricity-prices-more-than-2x-the-national-average/
[5]https://oilprice.com/Energy/Energy-General/California-Power-Bills-Are-Soaring.html
[6]https://www.sandiegouniontribune.com/2024/03/10/heres-how-many-san-diego-customers-are-behind-on-their-utility-bills/

Residential average rates have significantly increased

	Average Rate ($ per kWh)	3-year Change Jan 2021 to Jul 2024	10-year Change Jan 2014 to Jul 2024
PG&E	$0.367	↑ 51%	↑ 110%
Southern California Edison	$0.332	↑ 51%	↑ 90%
SDGE	$0.383	↑ 20%	↑ 82%

As shown in the table above,[7] residential electricity rates in California have risen dramatically. The average rate across the utilities has doubled over the last ten years[8] and this trend is likely to continue without significant reforms.[9]

Recent rate increases are a result of various market changes. Demand for electricity has surged after decades of relatively slow growth.[10,11] A recent Grid Strategies report[12] forecasts that power demand will double nationwide within the next five years, accompanied by significant growth in peak demand. This increase in demand is driven by the urgent need to reduce climate pollution via electrifying manufacturing, industrial processes, home appliances (e.g. heat pumps and induction stoves), and transportation (e.g. electric cars and buses), as well as the proliferation of energy-intensive technologies like data centers, artificial intelligence (AI),[13] and cryptocurrencies like Bitcoin.

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[7] https://www.publicadvocates.cpuc.ca.gov/-/media/cal-advocates-website/files/press-room/reports-and-analyses/240722-public-advocates-office-q2-2024-electric-rates-report.pdf

[8] A recent study shows that electric utility bills' inflation over the last ten years in California was roughly 2.5 times greater than the rate of inflation as measured by the Consumer Price Index (CPI).

[9] https://www.energytoolbase.com/blog/utility-rates/electric-utility-bill-inflation-in-california/

[10] https://www.nytimes.com/interactive/2024/03/13/climate/electric-power-climate-change.html

[11] https://www.washingtonpost.com/business/2024/03/07/ai-data-centers-power/

[12] https://gridstrategiesllc.com/wp-content/uploads/2023/12/National-Load-Growth-Report-2023.pdf

[13] https://www.washingtonpost.com/business/2024/06/21/artificial-intelligence-nuclear-fusion-climate/

Large-scale, centralized power projects typical of the bulk power system — as well as the transmission[14] lines that they depend on — take years to develop and cannot keep pace with the accelerating growth in demand. The mismatch between surging demand and slow supply growth will lead to severe economic and environmental repercussions if not addressed swiftly.[15]

A more cost-effective, equitable, and environmentally sensitive approach is to emphasize the deployment of as many local DERs as possible to meet local loads,[16] prioritizing working-class communities. Transmission-based resources would supplement as needed. Local deployment of energy resources would reduce or avoid the costly "big-wire" connections and will be faster to build, have less environmental impact, and be more responsive to local electrical growth demands. Local deployment would also reduce costs and redirect customer energy expenditures toward investments in their local economies.

The Climate Crisis

The climate crisis, bringing with it greater weather volatility and extremes, creates new demands on the grid. Climate change has led to record-breaking drought,[17] extreme heat waves, floods, fires,[18] smoke storms, and high winds in California. Power interruptions during these events cause significant financial hardships and damages to human health and the environment.[19] As climate change rapidly worsens, these extreme events are already increasing in frequency and intensity.

To bolster the reliability of its power grid, California needs to develop a diverse and resilient portfolio of energy resources. This strategy can be effectively implemented through geographic diversification and flexible resource allocation. By distributing energy resources across various locations, California can reduce vulnerability to localized disruptions and take advantage of regional strengths in renewable energy production.

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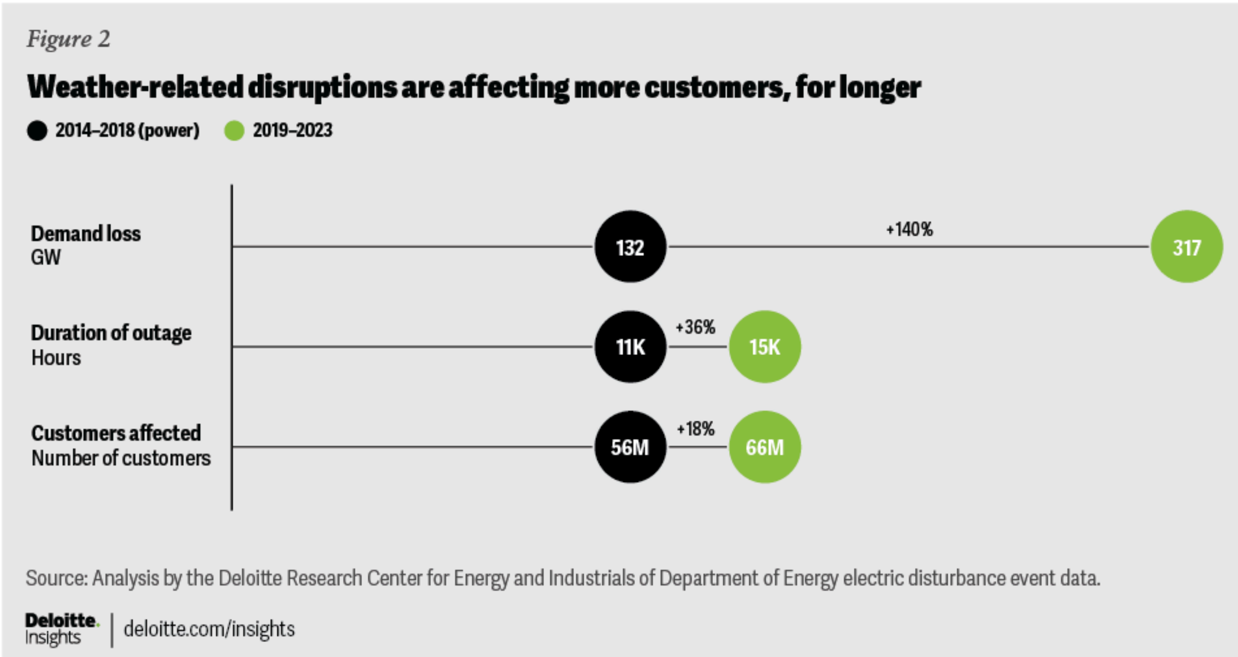
[14]Transmission infrastructure carries electricity from the site of generation to the substation, while distribution infrastructure carries electricity from the substation to the end user.
[15]https://www.nytimes.com/interactive/2024/03/13/climate/electric-power-climate-change.html
[16]Loads are the devices or appliances that consume electrical power in a circuit.
[17]Williams, et al. Large contribution from anthropogenic warming to an emerging North American megadrought. Science. 17 Apr 2020. The western U.S. is locked in the grips of the first human-caused megadrought, study finds. Washington Post. 16 Apr 2020
[18]Goss et al. Climate change is increasing the risk of extreme autumn wildfire conditions across California. Environmental Research Letters Mar 2020. Climate Change Has Doubled Riskiest Fire Days in California, E&E News, Apr 2020
[19]https://www.psehealthyenergy.org/preventing-wildfires-with-power-outages-the-growing-impacts-of-californias-public-safety-power-shutoffs/

The graph below illustrates how extreme weather events are increasingly disrupting the power grid.[20]



California continues to lead the nation in ambitious climate policy, with SB 32 setting a target of reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030.[21] While this target is insufficient to address our deteriorating climate reality (as CARB acknowledged in the 2022 Scoping Plan, in which it set a goal of 48 percent reduction by 2030), even cutting emissions by 40 percent presents a significant challenge. The state must triple its current rate of emissions reduction to 4.4 percent each year until 2030 to meet this deadline.[22]

Decarbonizing the electrical grid is at the heart of this effort. Fortunately, technological advances have greatly enhanced the capabilities and dramatically reduced the costs of clean energy resources such as solar and wind as well as batteries, making these clean energy sources available night and day throughout the year. These advances have fundamentally altered the economic landscape, making clean power more competitive than fossil fuel alternatives and significantly lowering the cost of decarbonization.

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[20]The data in the graph uses national data. For California, public data is available on SAIDI and SAIFI. SAIDI is the average outage duration per customer served in minutes. SAIFI is the average number of interruptions a customer experiences in a year. These graphs using PG&E data do not account for planned power outages, which have increased in frequency as well. These data and graphs can be found at https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/infrastructure/electric-reliability-reports/2022-pge-annual-electric-reliability-report.pdf

[21]Revisions to the current cap and trade regulations consider a preferred allowance pathway that would deliver a 48 percent reduction in greenhouse gas emissions by 2030, if adopted.

[22]https://www.next10.org/sites/default/files/2024-03/GII2023-Print-Summary-web.pdf

The Environmental Justice Crisis

Emissions from polluting, fossil-fueled power plants result in environmental harm and injustice to the surrounding communities.[23] There are many dimensions to these environmental injustices. Fossil fuel pollution contaminates air and water, leads to serious health impacts, and lowers quality of life. There are inequities that result from the lack of energy security due to unaffordable electricity rates and lack of access to relief from planned or unplanned power interruptions. Low household wealth makes it incredibly difficult for communities to shield themselves from health, economic, and environmental burdens. To remedy these harms, California must replace polluting power plants with clean alternatives in these communities.

Peaker plants — which operate during periods of high electricity demand, often in evenings and during heat waves — emit significant pollutants during their short but intensive periods of operation.[24] The plants are predominantly located in low-income neighborhoods of color whose residents experience higher rates of respiratory illnesses linked to air pollution. In addition to peaker plants, standard Combined Cycle Natural Gas plants that operate all day have even higher total emissions.

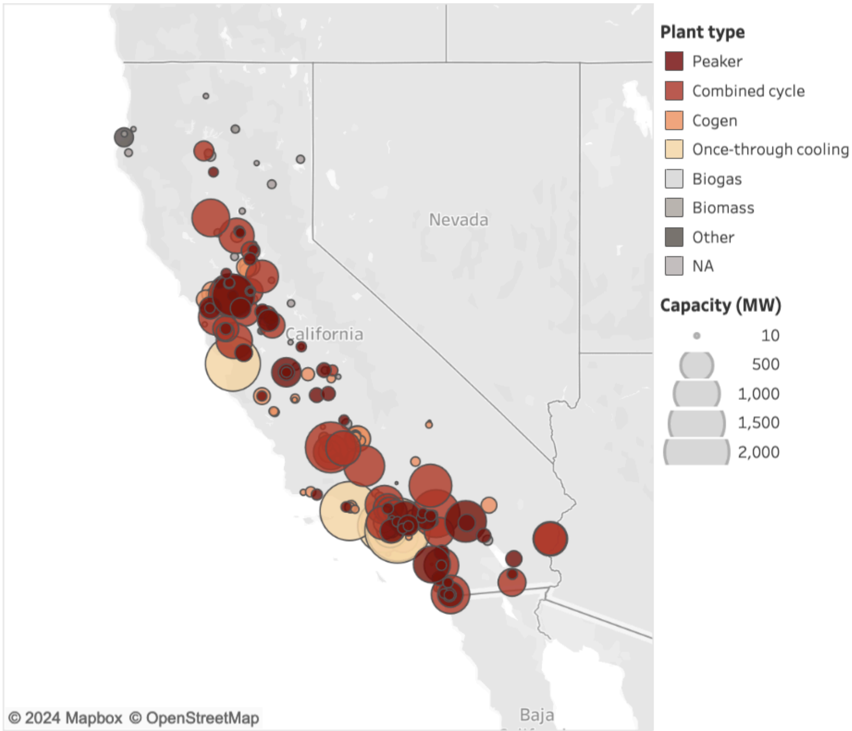
The graphic below shows the locations of California's peaker plants and Combined Cycle as well as other fossil fuel plants. Note that half of the peaker plants are sited in disadvantaged communities as defined by the state.[25]

[23] https://www.epa.gov/power-sector/power-plants-and-neighboring-communities

[24] For example, the continued use of peaker plants results in hazardous pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter ($PM_{2.5}$). These emissions exacerbate local air quality conditions, especially on days when ozone concentrations already exceed federal standards. Furthermore, these plants are concentrated in non-attainment areas with historically poor air quality. In addition, this pollution leads to serious health consequences including asthma, heart disease, miscarriages, and more.

[25] Graphic Source: PSE Healthy Energy.

California fossil fuel and bioenergy plants



The climate and environmental justice crises require that California significantly reduce *all burning of fossil fuels*, prioritizing the largest emitters impacting the most burdened and disadvantaged communities.

Improving local air quality requires a multifaceted approach, including stricter emissions controls, investment in clean energy alternatives, and involvement of affected communities in the decision-making processes regarding energy infrastructure. A just transition to cleaner energy sources demands consideration of the overall environmental impacts and the equitable distribution of both benefits and burdens across all communities.

The New Economics and Technology Driving These Changes

Significant economic and technological changes are fundamentally reshaping the economics of energy markets. The financial and environmental costs of fossil fuel technologies are becoming increasingly uneconomic. Fossil fuel markets are unpredictable. They are subject to dramatic price swings driven by geopolitical tensions, supply disruptions, and speculative trading. Fossil fuels also have substantial environmental and health costs not captured by their market price. These hidden costs are passed on to society as externalities.

Meanwhile, major advances in renewable energy technologies are leading to a new energy supply landscape where small is beautiful, flexible, and reliable.

The Falling Cost of Renewables and Batteries

Renewable energy alternatives are gaining momentum. Solar and wind power are increasingly cost-effective, often outperforming fossil fuels in the levelized cost of energy, which is the average total cost of building and operating an energy-generating asset per unit of total electricity generated over an assumed lifetime.[26,27]

Solar is now the cheapest form of electricity globally[28] and it is cheaper to build new solar than to operate existing fossil fuel plants.[29,30] Ongoing innovations in renewable energy technologies continue to improve efficiency, widening their cost advantage over fossil fuels. As clean energy production expands, it benefits from economies of scale[31] and experience curve effects,[32] further enhancing its economic advantage. The graph below shows the emerging cost advantage of renewables.[33]

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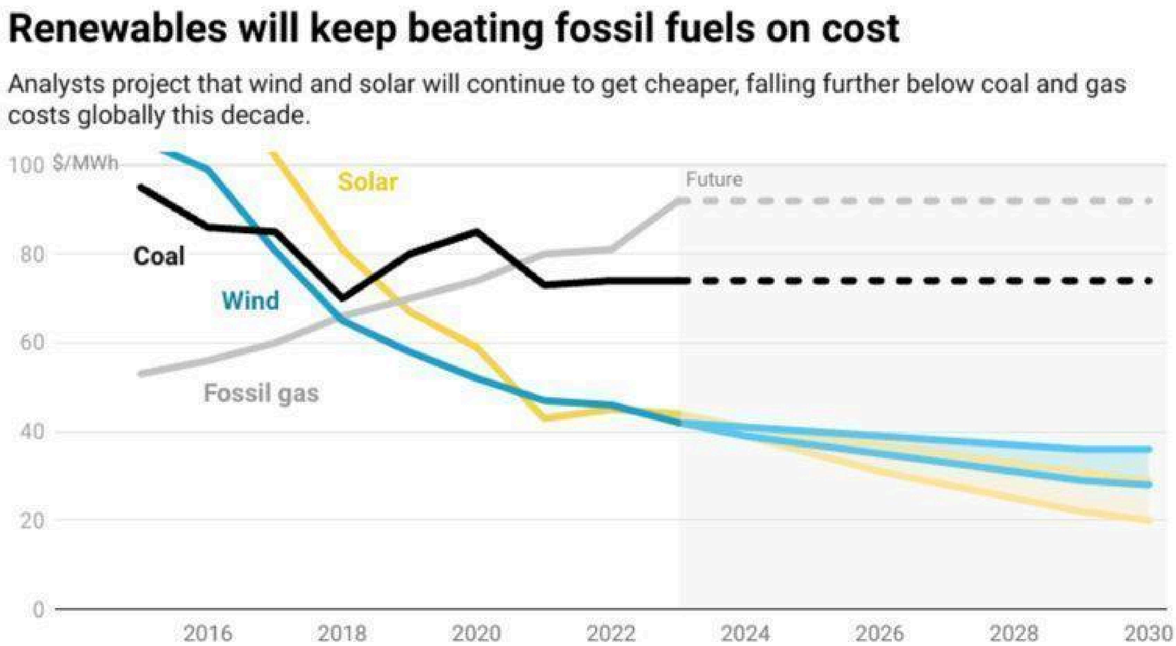
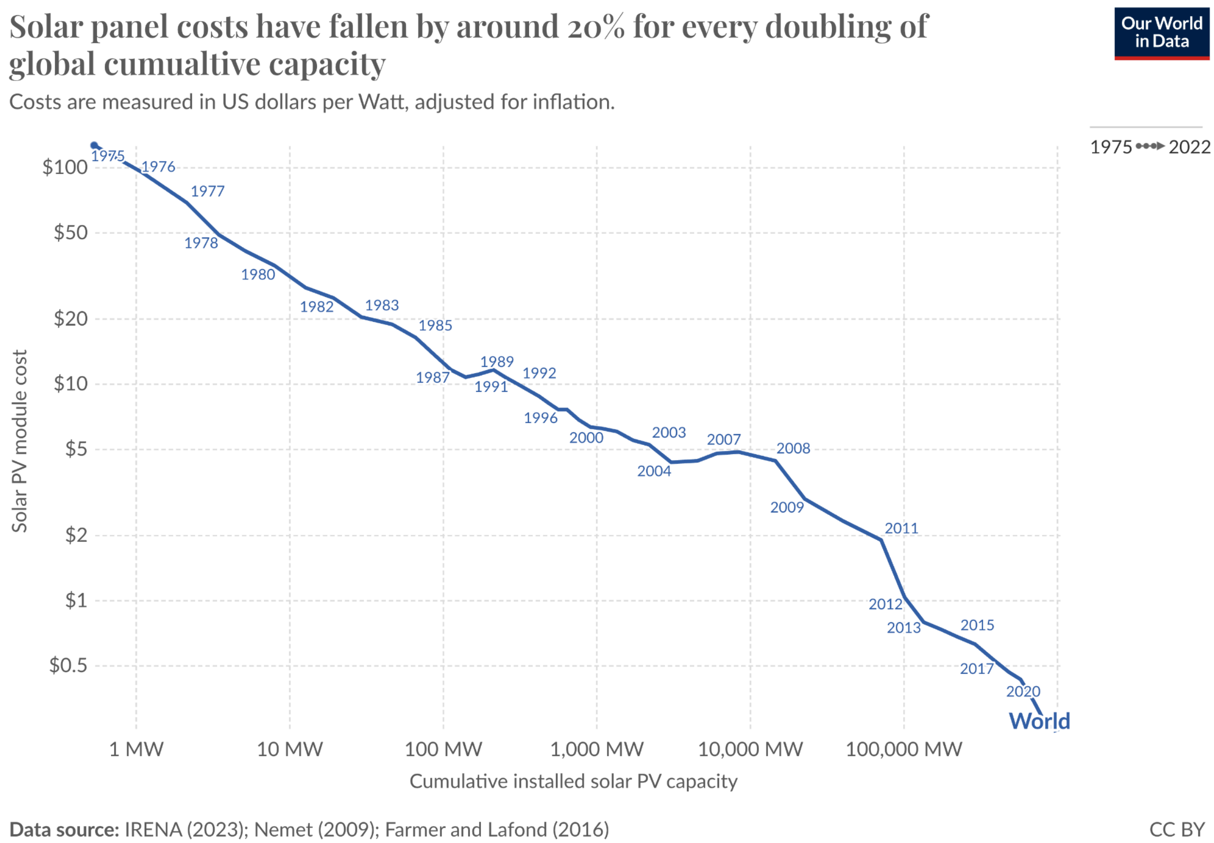
[26] https://corporatefinanceinstitute.com/resources/valuation/levelized-cost-of-energy-lcoe/#:~:text=Alternatively%2C%20the%20levelized%20cost%20of.a%20project's%20net%20present%20value.
[27] https://rmi.org/wp-content/uploads/dlm_uploads/2024/06/RMI_cleantech_revolution.pdf
[28] https://www.carbonbrief.org/solar-is-now-cheapest-electricity-in-history-confirms-iea/
[29] www.bloomberg.com/news/articles/2023-01-30/new-us-solar-and-wind-cost-less-than-keeping-coal-power-running
[30] https://www.bloomberg.com/news/articles/2021-06-23/building-new-renewables-cheaper-than-running-fossil-fuel-plants
[31] Scale economies are cost advantages that a given company gets as it expands production (lower unit costs).
[32] The experience curve illustrates the relationship between cumulative production experience and the average cost per unit of production. It suggests that the more experience a company has in producing a product, the cheaper it can produce each unit of the product, largely due to learning by doing, standardization, and innovation.
[33] https://www.canarymedia.com/articles/clean-energy/charts-renewables-are-on-track-to-keep-getting-cheaper-and-cheaper



The dramatic decrease in the cost of renewables is aiding the transition to clean power. The cost of batteries to back up solar arrays has fallen by an astounding 99 percent over the last 30 years, while their energy density has increased fivefold.[34]

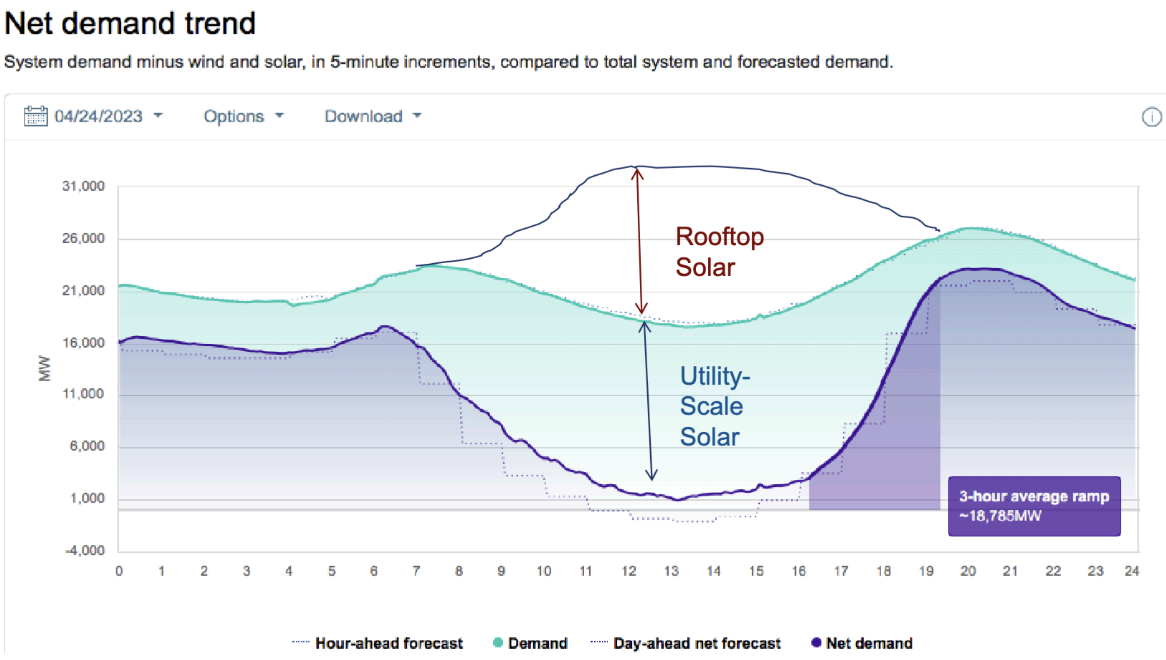
[34]https://energypost.eu/batteries-are-still-getting-exponentially-cheaper-more-efficient-ready-to-displace-half-of-global-fossil-fuel-demand-by-2045/

The graph below shows the remarkable decline in worldwide solar panel costs.[35]



The potential scope and scale of solar and other clean energy resources is enormous. With future decreases in costs and improvements in flexibility, the deployment of solar and batteries can be expected to grow exponentially.[36]

[35] https://ourworldindata.org/data-insights/solar-panel-prices-have-fallen-by-around-20-every-time-global-capacity-doubled
[36] https://www.reuters.com/business/energy/tumble-storage-battery-costs-boost-shift-renewables-says-iea-2024-04-25/



The graphic above illustrates the extent to which solar power is able to meet system demand during daylight hours in California.[37]

The Cost Inefficiencies of Big-Wire Infrastructure

The reliance of fossil fuel plants on expensive, “big-wire” transmission lines adds costs and administrative burdens not present in non-wired options. “Not In My Backyard” (NIMBY) activism presents a formidable barrier to new transmission line construction.[38] Communities frequently resist hosting high-voltage power lines, leading to prolonged approval processes and project delays. Multi-jurisdictional infrastructure projects involve protracted negotiations, legal disputes, and extended timelines.[39]

Recent trends have added even more costs to these resources. The rising price of raw materials has significantly increased expenses for capital-intensive, “steel-in-the-ground” projects. All these factors enhance the relative cost-effectiveness of local, clean energy resources compared to grid-connected power plants reliant on extensive transmission networks.

The financial costs of ignoring the increasing competitiveness of local-scale renewables and other DERs will be a severe and increasing financial burden on local communities and society.

[37] https://s3.us-east-1.amazonaws.com/fonteva-customer-media/00Do0000000Yi66EAC/JljTYcOs_FINAL_DER_BOOTCAMP_pdf
[38] https://epic.uchicago.edu/news/transmission-not-in-my-backyard/
[39] https://pv-magazine-usa.com/2024/04/11/renewables-and-storage-interconnection-backlog-grew-about-30-last-year/

Local DERs and microgrids resolve many of the issues associated with large, utility-owned, transmission-connected resources. DERs are cheap and getting cheaper. They will advance California's climate goals and will help achieve the state's air quality targets. And they can be built quickly, located close to load centers, and — in some cases — can even be mobile, enabling them to bolster community energy resilience. The financial benefits of harnessing the energy from batteries in electric vehicles alone is enormous. According to California analysis from the Electric Power Research Institute,[40] the potential annual benefits of vehicle-to-grid (V2G) technologies to California ratepayers — based on assumptions regarding the number of electric vehicles and the percentage of them which are V2G enabled — are approximately $670 million in the medium forecast and just over $1 billion in the high forecast.

Transitioning to a more democratized energy system gives consumers greater control over energy usage. DERs, often installed "behind the meter" at the customer's premises, provide consumers with direct management of their energy consumption and production. This consumer agency is absent in the current top-down, utility-owned structure. With proper financial incentives, customers will be motivated to actively manage their energy consumption via load shifting to off-peak hours. The resulting cost savings will bring economic benefits for both consumers and producers.

Perverse Incentives for Business as Usual

Current regulations perversely promote and reward investor-owned utility "business-as-usual" investments in large, capital-intensive, risky projects. Even more troublesome is the fact that newly enacted regulations prohibit consideration of more cost-effective DER alternatives in planning.[41,42] Continuation of these flawed policies will incentivize energy-intensive business and residential customers to defect from the grid at the same time the state is authorizing more transmission-level investments. The result will further increase costs for those remaining on the grid and lead to financial havoc as stranded cost recovery[43] threatens the stability and viability of the whole energy supply system. This is bad policy and needs to be corrected.

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[40] https://www.epri.com/research/products/000000003002014771

[41] https://www.microgridknowledge.com/microgrid-policy/article/55089139/california-microgrid-der-community-seeking-legislative-reversal-of-cpuc-net-metering-decision

[42] https://www.microgridknowledge.com/policy/article/55141466/cpucs-proposed-microgrid-tariff-decision-seen-as-another-blow-to-meeting-california-climate-goals

[43] https://regulationbodyofknowledge.org/glossary/s/stranded-costs/#:~:text=Stranded%20Costs%20are%20costs%20that.shut%20down%20a%20generating%20facility).

Distributed Energy Resources Are Clean and Flexible

In addition to being cheaper than fossil fuels, DERs are non-polluting, flexible, modular, distributed in many places, and quick to build and install.

Examples of these innovations include consumer-scale photovoltaic (PV) and storage, battery storage, electric vehicles (effectively batteries on wheels), smart appliances, and microgrids (locally-connected, clean power generators). Batteries are particularly valuable since they enable load shifting, an energy management strategy that involves moving electricity consumption from one time to another, typically from peak demand hours to off-peak hours. This flexibility enables batteries to help stabilize the grid, provide backup power sources in emergencies, and shift load to cheaper time periods and to other locations, reducing vulnerability to large-scale outages.

Smart AI and software developments are further enhancing the value and flexibility of DERs, enabling them to be networked and configured so they can serve diverse load requirements and reduce costs by being used at the cheapest times of day. These smart network designs can be customized and scaled to meet load and service requirements of any size and configuration.

By enabling the greater integration and widespread adoption of renewable energy sources, DERs support the accelerated transition to a cleaner energy system. Realizing these benefits will require thoughtful policy frameworks, advanced grid management systems, and continued technological innovation to fully integrate and optimize these distributed resources within the larger energy ecosystem.

Energy Storage and Bidirectional Electric Vehicles

The integration of electric vehicles (EVs) into the power grid presents a transformative opportunity for EVs to help manage energy flows within the larger electricity system. This concept of "batteries on wheels" is gaining traction as EV adoption accelerates.[44] Bidirectional EVs serve not only as transportation of people and goods but also as mobile power units capable of addressing grid load needs. Unlike utility scale storage, EVs can be deployed rapidly to the location of need.

[44]Unlike most existing EV charging technology, which sends energy only in one direction — from a power source to a car's battery — bidirectional charging allows the vehicle to send that energy for use by other devices.

The California Energy Commission estimates that the state will have 8 million electric vehicles on the road by 2030.[45] If 5 million of those were bidirectional, their stored energy would be enough energy to power every home in California for a day. This calculation assumes an average 80 kilowatt-hours capacity per bidirectional EV, roughly 17 million housing units in California, and an average daily home energy consumption of 19 kilowatt-hours per day. For context, the state's largest electricity source, the Diablo Canyon nuclear power plant, can generate electricity at a maximum rate of 2.2 gigawatts. During a record-breaking heat wave in 2022, peak demand on California's grid reached 52 gigawatts, the highest in history.[46] If all 8 million EVs in 2030 were bidirectional, they would have as much as 80 gigawatts of energy capacity, assuming a 10 kilowatt-hour export per vehicle.

If there's a blackout or a Public Safety Power Shutoff, these bidirectional EVs could keep the lights on for Californians by islanding from the grid to power homes, buildings, hospitals, libraries, and other community resilience hubs.

Adding bidirectional capability to EVs can generate an enormous volume of useful capacity.[47] The graph below shows that total, nationwide EV battery capacity will exceed peak U.S. electricity demand in 2035, according to a 2022 forecast from the Electric Power Research Institute.[48]

This vast potential is just waiting to be put to good use. Currently, electric school buses and other EVs are sitting idle when not used for transportation. To take full advantage of EV batteries, we'll need better policies on interconnection and compensation,[49] as explained in the next section of this paper.

Furthermore, these underutilized resources can meet demand in a way that is affordable, non-polluting, and without the environmental and economic inequities of the current grid structure. California already has more than 3,000 electric school buses on the road, the most of any state in the nation. California has an opportunity to model for the nation that their batteries can be leveraged to shore up the grid.

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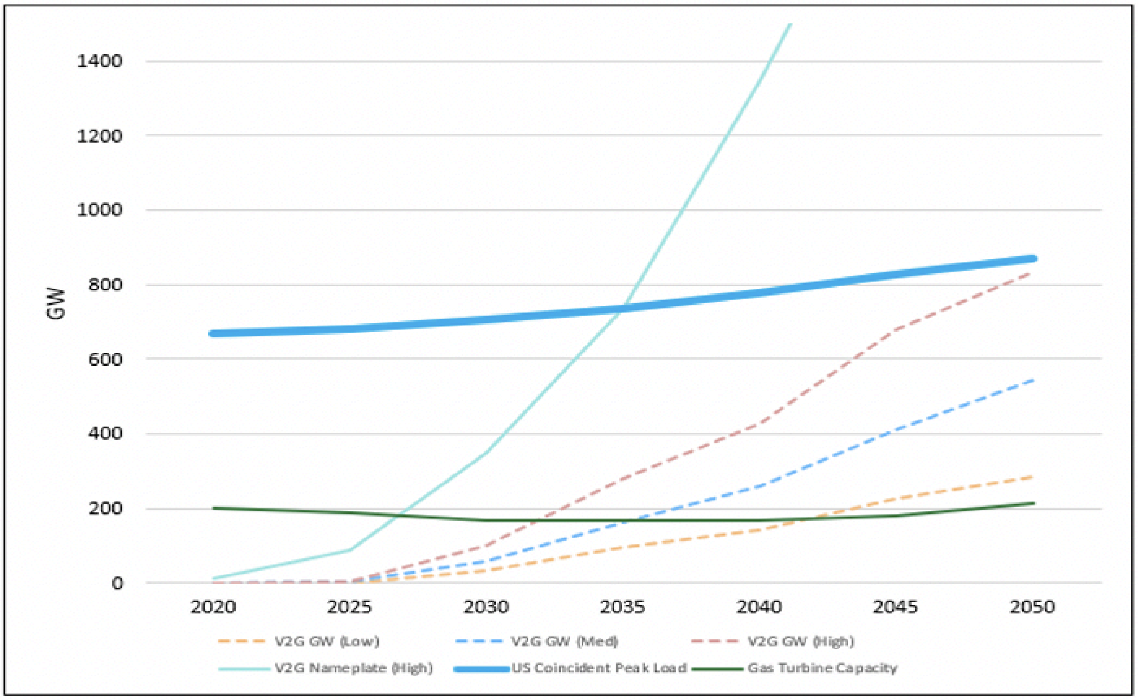
[45] https://www.energy.ca.gov/data-reports/reports/electric-vehicle-charging-infrastructure-assessment-ab-2127/evse-deployment and https://calmatters.org/environment/2023/01/california-electric-cars-grid/

[46] https://www.utilitydive.com/news/california-iso-narrowly-avoids-outages-but-warns-as-peak-demand-hits-record/631280/

[47] For example, California sees very significant amounts of renewable curtailment, particularly in the Spring. In April 2023, the amount of solar and wind that was curtailed would have been enough to charge every EV in California with 80 miles of range every day of the month. V2G can enable EVs to capture this excess renewable generation and save it for periods of the day when demand is high.

[48] Presented at an October 2022 EPRI Webex. Based on EIA projections of EV populations

[49] https://www.microgridknowledge.com/electric-vehicles/article/55234119/california-bill-supports-ev-bidirectional-charging-but-incentives-and-regulations-needed-to-realize-benefits



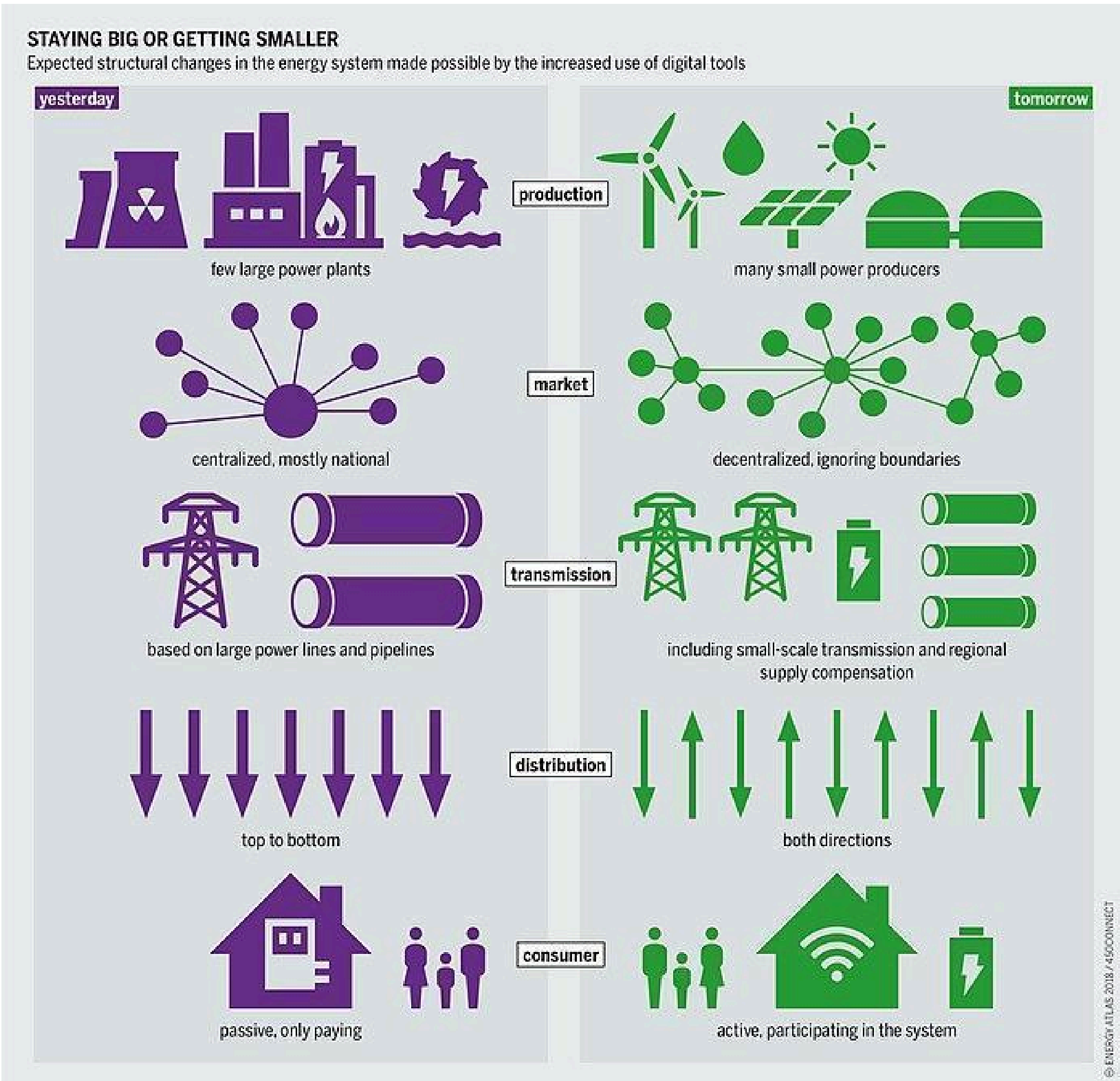
To unleash this enormous potential, California should reform its grid architecture, planning, rules, and regulations so that DERs can be optimally deployed.

Key Reforms Needed to Integrate Distributed Energy Resources

Enable Bidirectional Energy Flows and Trading

In an energy ecosystem with integrated DER resources, loads become flexible, meaning that DERs can either add to or subtract from electric loads. With traditional, central grid management, electric supply resources are strictly one-way from substation to consumer. This growing capacity for bidirectional energy flows or interactions introduces a whole new world of possibilities for energy services and management.

To attain these benefits, California must reform grid planning architecture, develop new operating procedures, remove regulatory barriers, and craft innovative compensation systems for all market participants. The diagram below illustrates the structural changes needed for society to fully benefit from smart DERs with advanced technological capabilities.[50]



[50]https://gef.eu/wp-content/uploads/2018/04/energyatlas2018_facts-and-figures-renewables-europe.pdf

New Grid Architecture

California's current grid architecture has major limitations. Existing regulations hinder the ability of local area resources to commercially operate and compete with other resources.[51] These restrictions impose unnecessary costs on communities by overlooking more cost-effective local resource options and by burdening customers with transmission-related expenses for services they may not require. What is particularly egregious is that lower-income and disadvantaged communities bear the brunt of these inefficiencies, exacerbating existing inequities.

California needs a new grid planning architecture that allows all resources to compete fairly in providing energy services. These include "big-wire" transmission line expansions, "small-wire" options catering to dispersed loads, and "non-wire" solutions whereby local area networks are aggregated into Virtual Power Plants (VPPs). Virtual Power Plants are collections of coordinated DERs whose aggregate energy generation can provide many of the same services as a traditional power plant.[52]

As an example, consider the scenario of a planned community center seeking bids to meet its specific load requirements. Potential bidders in this expanded marketplace would include aggregated demand-side load management[53] (e.g. heat pumps, weatherization), community rooftop solar with storage, an onsite solar array with storage, a local microgrid with excess capacity, and a traditional, wires-connected central utility plant (with upgraded transmission lines). The community center would be able to choose the combination of resources for its operation that balance its needs for affordability, resilience, and sustainability.

One way to support this resource integration is to develop an "open-access" transactive distribution network,[54,55] as proposed by Lorenzo Kristov, a former Principal in market design and infrastructure policy at the California Independent System Operator (CAISO). Under this arrangement, the management of local distribution area resources would be entrusted to an Open Access Distribution System Operator (DSO). The DSO would collaborate with the Independent System Power (CAISO in California) responsible for balancing the overall energy grid.

In this model, the bulk power system oversees the regional, big-wires operations and the wholesale competitive power market. Local area needs would be met through various sources,

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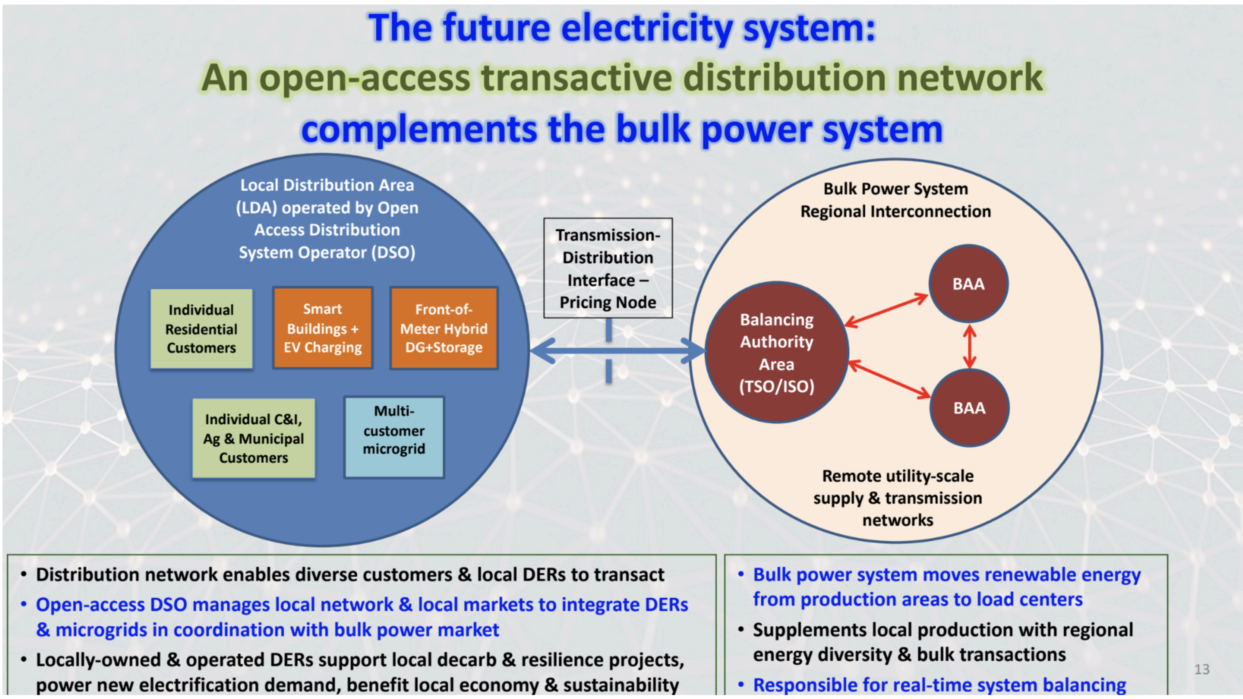
[51]For example, existing regulations prohibit multi-property microgrids that could cost effectively meet community energy needs. These constraints increase energy costs for everyone.
[52]https://rmi.org/big-wires-small-wires-and-non-wires-solutions-to-electrify-everything/
[53]Demand-side load management is the process of balancing the supply of electricity on the network by adjusting the load.
[54]https://drive.google.com/file/d/1-MiiGu8ndcCdNAOKliDZJj2rwoObrx18/view?usp=sharing
[55]https://energy.ucdavis.edu/energy-bites-seminar-may-9th-2024/

including big-, small-, and non-wire resources, all competing through the DSO. The following schematic diagram illustrates how the DSO can balance and manage these resources.[56]



Integrating an expanded set of resource options into system and local grid planning improves demand flexibility and resilience. In addition, multiple recent reports demonstrate that such integration lowers overall system costs. [57,58,59]

Compensation Reforms

Compensation reform is necessary to create incentives for market agents to supply electricity to the grid, recognizing both the timing and location of energy delivery.

For example, compensation reform could enable a solar photovoltaic owner with a battery to earn money by feeding energy into the grid when resources are constrained, or an EV owner could earn income by providing back-up services when there is an outage. These new revenue

[56] https://energy.ucdavis.edu/energy-bites-seminar-may-9th-2024/
[57] https://www.brattle.com/wp-content/uploads/2023/04/Real-Reliability-The-Value-of-Virtual-Power_5.3.2023.pdf
[58] https://www.brattle.com/wp-content/uploads/2024/04/Californias-Virtual-Power-Potential-How-Five-Consumer-Technologies-Could-Improve-the-States-Energy-Affordability.pdf
[59] https://www.smart-energy.com/industry-sectors/energy-grid-management/tripled-vpp-capacity-can-save-10bn-in-grid-costs-finds-us-energy-department/

sources will lower energy costs for consumers by providing new income streams to offset any investment costs.

Limited examples of this capability exist now with time-of-use schedules that enable consumers to replace expensive power with cheap power. Future electricity rates, or tariffs,[60] will need to be itemized, or "unbundled," to allow each type of service to be individually priced. This has been described as the "value stack" approach,[61] in which value is assigned to different attributes that the resource provides.

New York's value stack[62] program exemplifies the type of tariff structure that can support the new paradigm. This program ensures that energy providers receive compensation not only for the energy they generate, but also for the various additional benefits they convey to the local energy grid, including non-energy benefits.[63] These benefits include capacity enhancement, environmental advantages, demand reduction, and relief to the system's location-specific challenges. This comprehensive compensation approach serves to encourage the efficient deployment of DERs by remunerating them for the benefits they provide in meeting peak demand (capacity value) and by reducing the need for transmission and distribution infrastructure through the strategic location of resources in constrained areas (location value).

[60] A utility tariff governs how an energy provider (electric or natural gas) charges the customer for their energy.
[61] https://legal-planet.org/2024/09/24/community-solar-compensation/
[62] https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources
[63] In California, non-energy benefits are now being considered to "determine methodologies to integrate [non-energy benefits (NEBs)] and social costs into the CEC's resource planning and investment decision-making processes," including any cost-effectiveness determinations made by the CEC.
https://acrobat.adobe.com/id/urn:aaid:sc:VA6C2:e058bfa4-5625-434f-9441-7eb85d1fbc8b

The table below[64] shows how the value stack pricing mechanism allocates compensation for the various market attributes provided by energy resources.

Value Name	Description	Eligible DERs
Energy Value (LBMP)	LBMP is the day-ahead wholesale energy price as determined by NYISO. It changes hourly and is different according to geographic zone.	All technologies: PV, storage, CHP, digesters, wind, hydro, and fuel cells.
Capacity Value (ICAP)	ICAP is the value of how well a project reduces New York State's energy usage during the most energy-intensive days of the year. Developers can choose from three payout alternatives and most ICAP rates change monthly.*	All technologies receive ICAP. Dispatchable technologies (stand-alone storage, CHP, digesters, and fuel cells) will receive Alternative 3.
Environmental Value (E)	E is the value of how much environmental benefit a clean kilowatt-hour brings to the grid and society. The E value is locked in for 25 years.**	PV, wind, hydro, and storage charged exclusively from PV or wind energy. Stand-alone storage is not eligible at this time.
Demand Reduction Value (DRV)	DRV is determined by how much a project reduces the utility's future needs to make grid upgrades. DRV is locked in for 10 years.**	All technologies.
Locational System Relief Value (LSRV)	LSRV is available in utility-designated locations where DERs can provide additional benefits to the grid. Each location has a limited number of MW of LSRV capacity available. The LSRV is locked in for 10 years.**	All technologies. Project must be on a utility-specified substation.
Community Credit (CC)	CC is available on a limited basis to encourage the development of Community Distributed Generation (CDG) projects. CC is the successor to the Market Transition Credit (MTC) and is similar in structure. The CC is locked in for 25 years.** PV projects in utility territories that have fully expended their CC may be eligible for the Community Adder – an upfront incentive administered by NY-Sun.	Available for CDG projects including PV and digesters. Wind, hydro, and fuel cells receive CC at a derated value. Not available for stand-alone storage or CHP.

For more information on the three ICAP alternatives, view the most recent Value Stack presentation slides on the Value Stack Resources page at nyserda.ny.gov/value-stack-resources

***Projects will lock in their E, DRV, LSRV, and CC values when they make their 25% upgrade payment to the utility. If no utility upgrade costs are required, the values are locked in when the interconnection agreement is fully executed.*

[64] https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources/Value-Stack-Resources

Going Forward: Changing Course

California must

- Dismantle regulatory roadblocks;
- Reform grid planning and architecture;
- Enable an open-access distribution network where electricity is bought and sold;[65]
- Acknowledge and compensate the full value of DERs; and
- Reform the ways in which utilities are compensated to incentivize least cost alternatives and better align with state climate goals for reliability, resilience and equity.

To reach California's goal of providing affordable, clean, and resilient energy, the state needs to change course. The new economics of energy markets dictate a shift toward non-polluting, flexible, modular, and local area distributed resources, which avoid the need for costly transmission connections. California needs to shift to a framework and planning infrastructure to enable these low-cost options to proliferate. Attaining the least cost resource portfolio requires compensation reforms for utilities and DER developers that recognize avoided costs to permit these local area resources to become financially viable.

During a transition period, the portfolio of resources will range from clean, non-emitting options — such as solar, wind, geothermal, nuclear, and hydroelectric power — to legacy fossil fuel plants. This portfolio will maximally utilize diverse, non-wire solutions that can meet local area energy needs via DERs such as microgrids and VPPs.[66] Where local resources cannot meet all demand, the rest can be met by expansion of transmission and distribution infrastructure. This would include rerouting lines to use transmission capacity from retired plants (e.g. coal plants), reconductoring[67] existing transmission lines with advanced conductors, and speeding up the permitting processes.

With a fully integrated energy system, all available resource options will compete to meet load when and where it is needed. An independent system operator like CAISO will still remain

[65] https://energy.ucdavis.edu/energy-bites-seminar-may-9th-2024/
[66] https://veckta.com/2021/05/20/virtual-power-plant/
[67] https://energyinnovation.org/publication/the-2035-report-reconductoring-with-advanced-conductors-can-accelerate-the-rapid-transmission-expansion-needed-for-a-clean-grid/

essential to orchestrate the overall system energy flows and balances, ensuring the stability and safety of the grid.

California must also make fundamental changes to the ways in which utilities are regulated and compensated. To motivate strategic, cost-effective deployment of all wired *and* non-wired resources, it is imperative that utilities and power agencies benefit from smart energy investment choices. In the case of regulated monopoly utilities, this will require replacing current cost recovery methods,[68] which are biased in favor of large, expensive infrastructure capital projects. The incentives are skewed because cost recovery is based on expenditures with a rate of return rather than performance or delivery of services.

Performance-based ratemaking (PBR) is an example of a better cost recovery option.[69] This regulatory approach aims to align utility incentives with the interests of customers and society. It does this by compensating utilities based on their performance against target outcomes rather than just costs and by removing perverse incentives.[70] With PBR, rewards can be constructed for a wide range of performance metrics, including rewards for costs saved rather than costs incurred. This approach would allow regulators to align utility compensation with the lowest cost alternative to meet the state's climate goals. Versions of PBR are already being used in other states.[71]

Conclusion

California stands at a pivotal juncture, facing two divergent energy policy paths: maintaining the status quo or overcoming the political influence of vested interests opposing change.

The latter would enable the rapid integration of DERs into the grid, which would fundamentally reshape our energy system, transforming passive loads into flexible, bidirectional assets capable of both supplying and saving electricity. The democratization of electricity supply will necessitate reform of the utility business model. It will require bottom-up system planning as well as compensation rules and regulations that enable DERs to be fully valued and integrated. With widespread adoption of DERs, California can reduce the need to build large-scale remote generation and expensive transmission lines.

With enough political will, California can realize the transition to a clean, affordable, reliable, resilient, and equitable electricity system that serves as a model for the nation and the world.

[68]This is commonly referenced as "cost of service" regulation.
[69]https://rmi.org/wp-content/uploads/dlm_uploads/2024/07/RMI_how_to_restructure_utility_incentives.pdf
[70]https://rmi.org/wp-content/uploads/dlm_uploads/2024/07/PBR_Deck_final.pdf
[71]https://rmi.org/states-move-swiftly-on-performance-based-regulation-to-achieve-policy-priorities/