Sapping California's Energy Future

Current energy mandates are incompatible with a modern, reliable energy system

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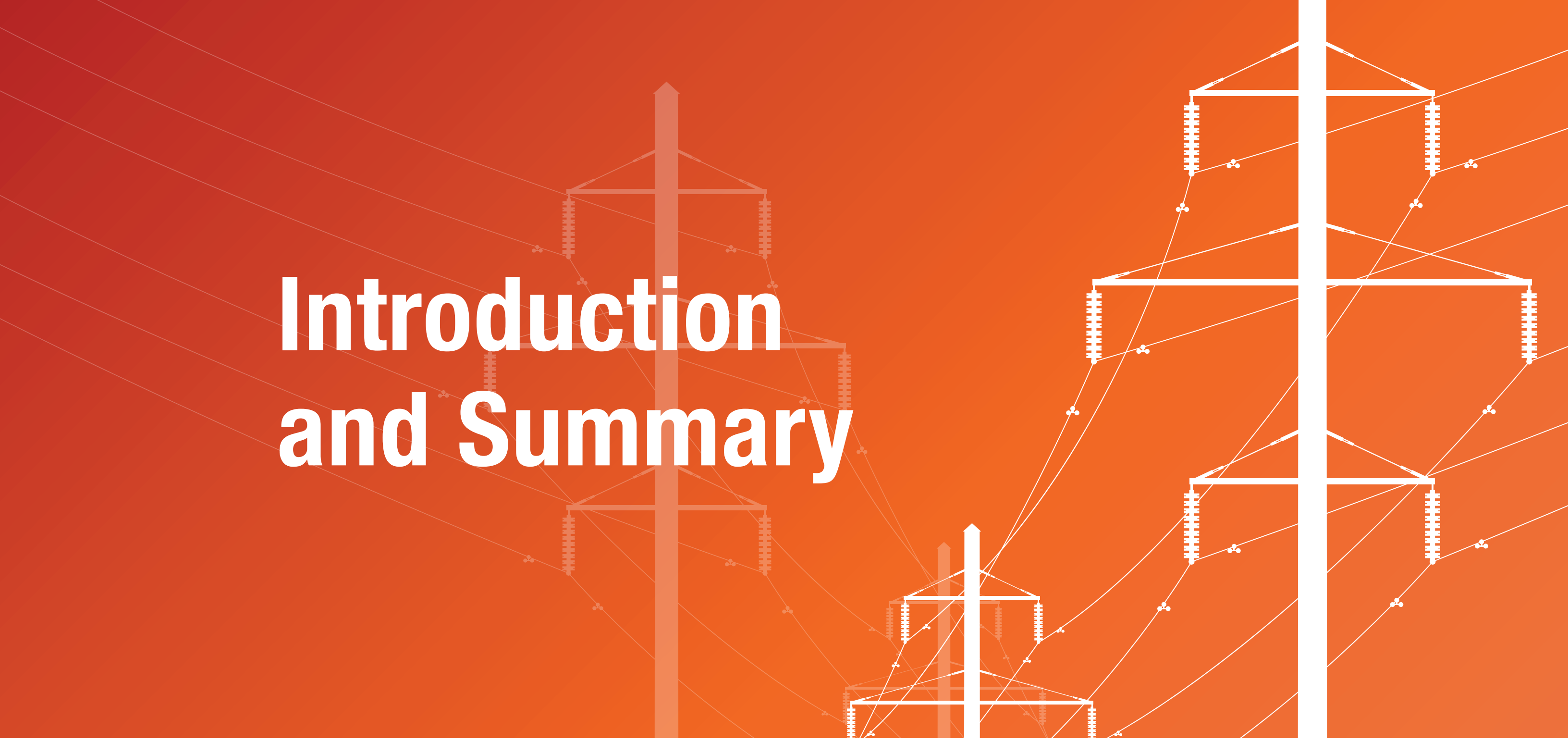

Introduction and Summary

In September 2020, California Gov. Gavin Newsom signed an executive order that requires every new passenger car and light truck sold in the state be a zero-emission vehicle by 2035. The order also requires the sales of all new medium- and heavy-duty vehicles, drayage trucks, and off-road vehicles to eventually be a zero-emission vehicle. Not quite two years later, the California Air Resources Board (CARB) unanimously approved the order, claiming to have set "California on a path to rapidly growing the zero-emission car, pickup truck and SUV market and deliver cleaner air and massive reductions in climate-warming pollution." Not satisfied with passenger cars and trucks, CARB voted in April 2023 to phase out the sales of heavy duty trucks by 2036.

No vehicle is a "zero-emission" vehicle once life-cycle emissions are properly considered. The extraction of the necessary rare earth elements and physical production of electric vehicles emit an exceptionally large amount of greenhouse gasses (GHG). Therefore, not one of the qualifying vehicles would be a true zero-emission vehicle.

> **"Beyond this reality, there is a more practical concern with the executive order—implementing the EV mandate, along with all the governor's other GHG emission policies, creates avoidable energy shortages both today and, without a miracle leap in our current technologies, well into the future."**

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For evidence, look no further than the actions taken by the organization that manages the state's electric grid—the California Independent System Operation (CAISO)—less than a week after the Aug. 25, 2022, CARB vote. CAISO asked the owners of electric cars to refrain from charging them during the hours of 4 p.m. to 9 p.m. so that energy could be conserved. This CAISO *Flex Alert* was issued to inform consumers about how and when to conserve electricity in response to rising temperatures, state wildfires sapping energy resources, and threatening rolling blackouts. Less than two weeks later, CAISO asked the state Department of Water Resources to deploy temporary emergency power generators to boost the fragile energy grid.

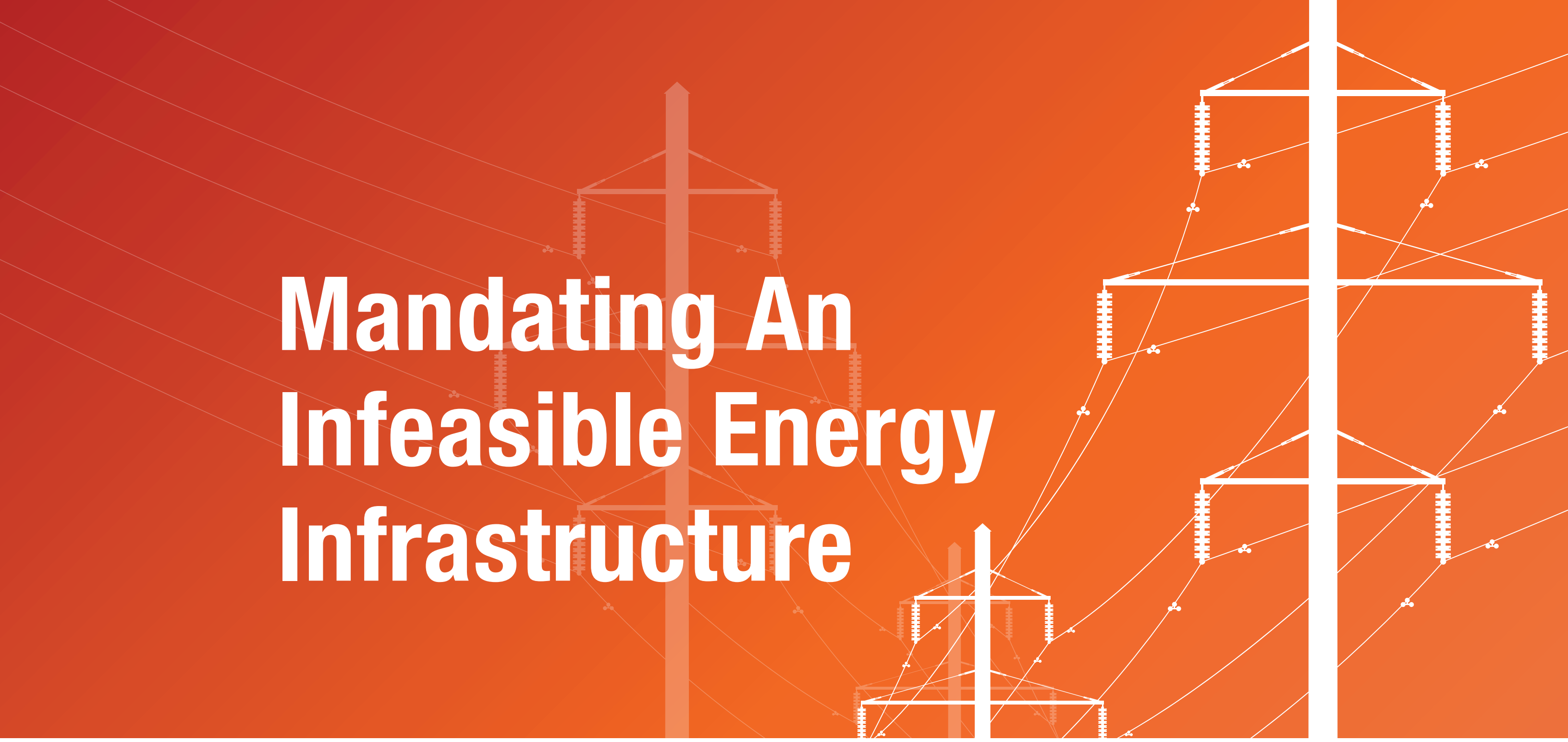
> **“It is highly doubtful that California will be able to meet its government-imposed renewable energy transition deadlines unless, based on our calculations, the state expands its annual addition of alternative energy sources by 86 percent.”**

The CAISO request creates skepticism that the state's plan to transition to 100 percent renewable power by 2045 while generating more energy to power a massive conversion to electric vehicles is feasible. A careful review of the current policy mandates, traditional and alternative energy generation sources, and realistic scenarios of the state's future energy needs substantiates this skepticism.

As will be discussed in detail in this paper:

- Even assuming all other state residential electricity consumption remains flat—the trend since 2006—our calculations find that the state will require a 20.2 percent expansion of electricity generation (from nearly 280,000 GWh based on historical consumption growth to an estimated over 336,000 GWh) to meet its electric vehicle mandates and the additional residential electric charging required by 2045.

- Phasing out fossil fuel and nuclear facilities and replacing this generation with solar and wind resources at its historic pace will cause total generation capacity to decline slightly, leading to a projected 21.1 percent generation deficit compared to demand by 2045. The need to balance electricity supply and demand on a second-by-second basis worsens this deficit significantly.
- Our calculations do not include the additional electricity required to meet mounting California green mandates, such as pending prohibitions on new gas-powered heaters and air conditioners, water heaters, lawn equipment, and stoves. Thus, California's real projected power deficit will be much larger when all mandates are factored in.
- It is highly doubtful that California will be able to meet its government-imposed renewable energy transition deadlines unless, based on our calculations, the state expands its annual addition of alternative energy sources by 86 percent.
- Policymakers should consider that many sources of renewable energy, such as wind and solar, are volatile and erratic, and will require significant investments in necessary infrastructure and land that will be very expensive, costs that will ultimately be borne by ratepayers.
- As one energy policy expert noted in recent testimony to Congress, upgrading the power grid for an all-renewable-energy future will require a scale comparable to a World War II level of mobilization, which will not be achievable given current regulatory hurdles, such as the California Environmental Quality Act.



Mandating An Infeasible Energy Infrastructure

Gov. Newsom's energy mandates maintain a long trend of policies that have continually added greater numbers of unachievable mandates that often contradict one another—as the box below illustrates. California's suite of edicts require more energy be provided by the electricity grid instead of fossil fuels, while simultaneously making it less and less likely that the grid can generate the required amount of electricity.

The predictable consequence from this combination of policies is now jeopardizing energy security in the state.

PARTIAL TIMELINE OF CALIFORNIA'S ENERGY MANDATES AND KEY REVERSALS

September 2006—Gov. Arnold Schwarzenegger signs Assembly Bill 32, which requires greenhouse gas emissions to be 25 percent below 1990 levels by 2020 (GHGs were just under 16 percent below 1990 levels in 2020).[1]

September 2016—Gov. Jerry Brown signs Senate Bill 32, which requires greenhouse gas emissions to be 40 percent below 1990 levels by 2030.

September 2018—Gov. Jerry Brown signs Senate Bill 100, which requires that "renewable energy resources and zero-carbon resources supply 100% of retail sales of electricity to California end-use customers and 100% of electricity procured to serve all state agencies by December 31, 2045." Interim targets for renewable energy sources are "50 percent by December 31, 2026, and 60 percent by December 31, 2030."[2] In December 2021, the California Air Resources Board set a more ambitious goal—48 percent of 1990 levels by 2030.[3]

September 2020—Gov. Gavin Newsom signs Executive Order N-79-20, requiring 100 percent of in-state sales of new passenger cars and trucks to be zero-emission vehicles by 2035, and mandating "that all operations of medium- and heavy-duty vehicles shall be 100 percent zero emission by 2045."

September 2020—The State Water Resources Control Board extended the lives of natural gas plants in Alamitos, Redondo Beach, Ormond Beach, and Huntington Beach that were scheduled to close.

August 2022—The California Air Resources Board codifies Executive Order N-79-20, which mandates that "100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035".[4] When Gov. Newsom signed Executive Order N-79-20 on Sept. 23, 2020, using the hood of a Ford Mustang Mach-E for a desk, he set the state on a path toward "35 percent ZEV sales by 2026, 68 percent by 2030, and 100 percent by 2035."[5] Initially, 100 percent of sales of new medium- and heavy-duty vehicle sales are to be ZEVs "for all operations where feasible" by 2040, but the Air Resources Board later proposed to accelerate the target to 2036.[6] The deadline for drayage trucks, which move cargo to and from seaports and rail yards, is a decade sooner. The state is also requiring a "transition to 100 percent zero-emission off-road vehicles and equipment by 2035 where feasible."[7]

The California Air Resources Board also voted to implement other mandates that will phase out the use of natural gas heating appliances throughout the state by 2030.

September 2022—Gov. Gavin Newsom signs Senate Bill 846, which delays the closing of the Diablo Canyon Nuclear Power Plant in San Luis Obispo County from 2025 to 2030.

September 2022—The Statewide Advisory Committee on Cooling Water Intake Structures recommended additional three-year extensions for natural gas plants in Alamitos, Redondo Beach, Ormond Beach, and Huntington Beach.

December 2022—The California Air Resources Board changes the 2030 emissions target to 48 percent of 1990 levels rather than the 40 percent specified by Senate Bill 32.

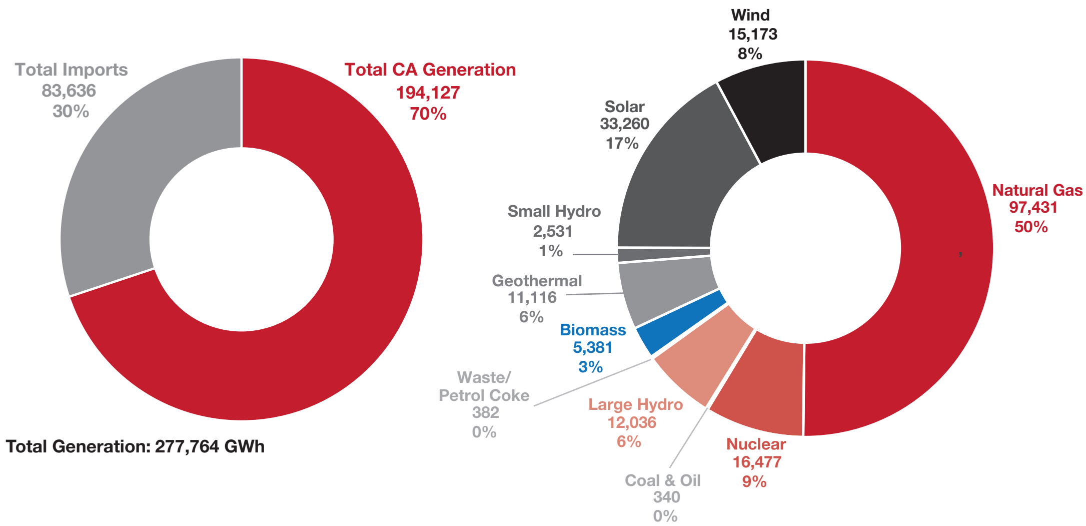
March 2023—The U.S. Environmental Protection Agency allows California to implement its zero-emission truck requirement. The rule requires truck manufacturers to increase zero-emission new truck sales to comprise 55 percent (Class 2b-3), 75 percent (Class 4-8), and 40 percent of semi-tractor sales by 2035. By 2045, zero-emission vehicles should comprise 100 percent of heavy-duty vehicles in California wherever feasible. Not satisfied with passenger cars and trucks, CARB voted in April 2023 to phase out the sales of heavy duty trucks by 2036.

Under A Best-Case Scenario, California's Energy Plans Do Not Add Up

Will there be enough power to meet demand? Can the state transition to a portfolio of 100 percent renewable energy sources and still generate enough electricity to meet the state's future needs, including the addition of millions of electric cars on the road? Using California's historical trends to project forward, the answer to these questions is no. Californians will face acute electricity shortages soon if policymakers insist on implementing its current suite of policies.

As Figure 1 illustrates, California is already incapable of generating enough electricity, importing 30 percent of its current electricity needs from other states. With respect to current generation sources, nearly 60 percent of California's in-state electricity generation is produced by natural gas and nuclear power plants. Including the conventional hydroelectric generation, which does not count as a renewable source for purposes of California's policies, nearly two-thirds of the state's current electricity comes from *disfavored* generation sources.

FIGURE 1. TOTAL CALIFORNIA ELECTRICITY GENERATION SOURCES: 2021



Source: Author calculations based on data from https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation

Under the plan, the current natural gas, nuclear, and de minimis amount of coal generation will be shut down and replaced with renewable sources by 2045. These renewable sources are defined to include "biomass, solar thermal, photovoltaic, wind, geothermal, fuel cells using renewable fuels, small hydroelectric generation of 30 megawatts or less, digester gas, municipal solid waste conversion, landfill gas, ocean wave, ocean thermal, or tidal current, and any additions or enhancements to the facility using that technology."[8]

Of the favored energy sources, solar and wind generation are the only growth sources. Geothermal, small hydro, and bioenergy facilities currently make up a small share of our energy mix and have been in overall decline over the past two decades.[9] In practice, then, solar and wind will need to generate nearly all the renewable power for this transition.

A fundamental consideration for the transition is sufficient battery storage. Meeting the state's electricity needs requires the grid to balance supply and demand on a second-by-second basis. Alternative energy sources such as wind and solar cannot generate electricity on demand—what is termed dispatchable sources. Instead, they generate electricity only when the wind blows or the sun shines. And there is no control over the amount of electricity these sources generate when the wind blows or the sun shines. These sources generate excess electricity when they work but no electricity at night and on cloudy days for solar and on windless days for wind.

Balancing a grid that relies exclusively on solar and wind sources on a second-by-second basis requires extensive battery storage as a result. With sufficient battery storage, the excess electricity generation that occurs on sunny and windy days can be stored and then dispatched when electricity is demanded. For California, the California Independent System Operator estimates that meeting its 2045 objective, "the Starting Point," requires "37 GW of battery energy storage, 4 GW of long-duration storage, over 53 GW of utility scale solar, over 2 GW of geothermal, and over 24 GW of wind generation—the latter split between out-of-state and in-state resources. The bulk of the in-state resources consist of offshore wind. These total 120.8 GW."[10]

One obstacle is whether this reliable battery storage infrastructure can be developed and built. As noted in the *MIT Technology Review*,

> these batteries are far too expensive and don't last nearly long enough, limiting the role they can play on the grid, experts say. If we plan to rely on them for massive amounts of storage as more renewables come online—rather than turning to a broader mix of low-carbon sources like nuclear and natural gas with carbon capture technology—we could be headed down a dangerously unaffordable path.[11]

Citing a 2016 study from researchers at MIT and Argonne National Lab, the authors continue that there are

> steeply diminishing returns when a lot of battery storage is added to the grid. They concluded that coupling battery storage with renewable plants is a "weak substitute" for large, flexible coal or natural-gas combined-cycle plants, the type that can be tapped at any time, run continuously, and vary output levels to meet shifting demand throughout the day.
>
> Not only is lithium-ion technology too expensive for this role, but limited battery life means it's not well suited to filling gaps during the days, weeks, and even months when wind and solar generation flags.
>
> This problem is particularly acute in California, where both wind and solar fall off precipitously during the fall and winter months.[12]

Reflecting these concerns,

> in *Utility Dive*'s 2020 State of the Electric Utility survey, 27% of participants said they expect their organization will significantly increase grid-scale battery storage in the next 10 years—***a significant reduction from 37% in 2018, and 34% in 2019*** (emphasis added). This is despite analysis by the U.S. Energy Information Administration, which forecast a spike in utility-scale battery storage beginning in 2021.[13]

In addition to these physical limitations, there are also economic constraints. As *S&P Global Market Intelligence* noted, the current demand for lithium-ion batteries for long-term storage—which has been accelerated by the passage of the Inflation Reduction Act—coupled with the need for these resources to build electric vehicles has caused the necessary materials to be in short supply.[14] Importantly, these shortages are expected to persist for many years into the future. The scarcity will increase the costs of building battery storage and decrease the likelihood that sufficient storage capacity can be built.

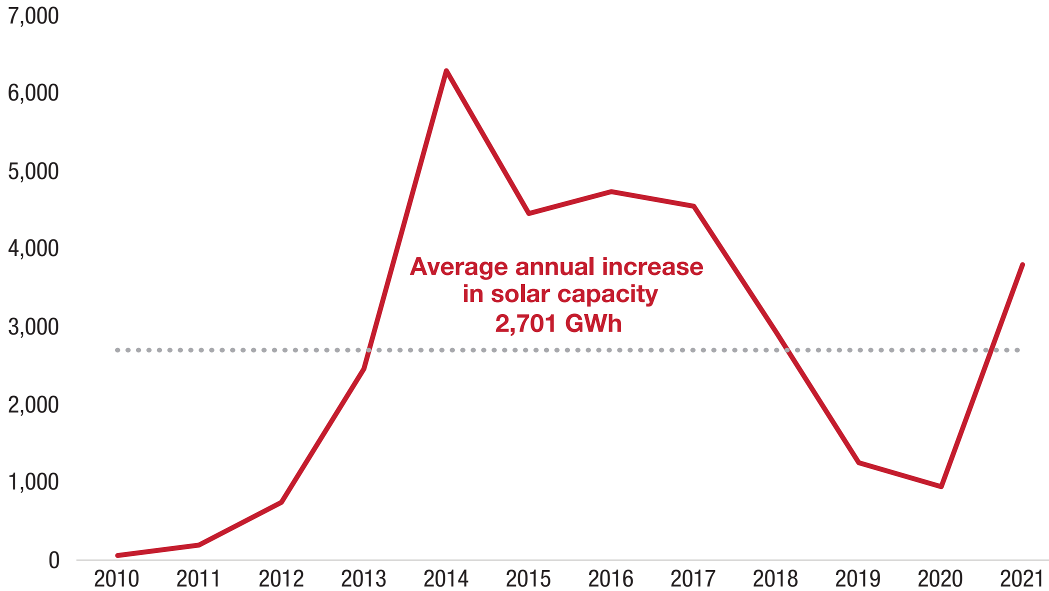
Sufficient battery resources are essential for ensuring that the generation capacity can be distributed when needed, not just when the alternative energy sources are producing electricity. The physical and economic obstacles to batteries raise serious concerns that California's grid will be unable to meet consumers' electricity needs on demand even if the system could generate adequate electricity. However, the state will not be able to generate sufficient electricity if it pursues its goals of shutting down its current natural gas, coal, and nuclear generation facilities, implements its EV sales mandates, and continues investing in its alternative energy generation facilities at its historical rate.

> **"The physical and economic obstacles to batteries raise serious concerns that California's grid will be unable to meet consumers' electricity needs on demand even if the system could generate adequate electricity."**

Given that California has been prioritizing building alternative energy sources, the recent annual pace of investment is assumed to be an accurate proxy for the number of alternative energy sources that the state will be capable of annually building in the future. To the extent that the state can accelerate its deployment of these assets, then the resultant electricity shortfall would be reduced. Closing the entire shortfall, as the below calculations demonstrate, requires that California expand its annual addition of alternative energy sources by 86 percent. The problems discussed in the following sections raise serious doubts that this increased pace of alternative energy plant generation can be achieved.

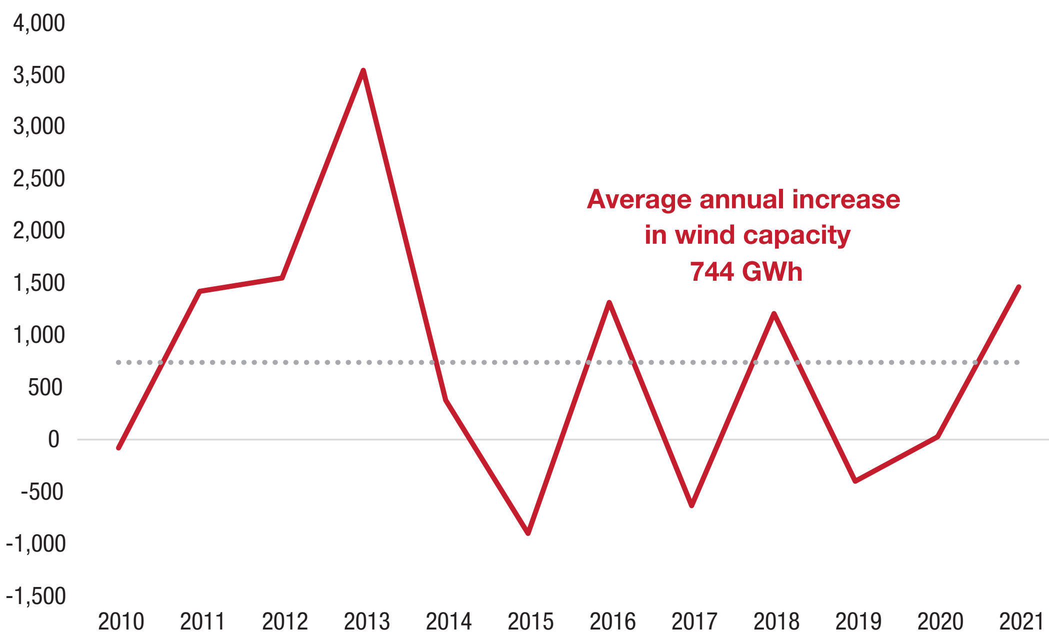
Figure 2 presents California's increases in solar generation capacity between 2010 and 2021. While the annual increase in capacity varies from year-to-year, on average the state has been capable of increasing its solar generation capacity by 2,701 GWh annually. As Figure 3 illustrates, California's addition of wind generation capacity has been even more volatile and averaged a smaller 744 GWh annually. In total, California has been able to increase solar and wind generation capacity by 3,444 GWh annually.

FIGURE 2. INCREASE IN CALIFORNIA'S SOLAR GENERATION CAPACITY, 2010—2021, (IN GWH)



Source: Author calculations based on data from, http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

FIGURE 3. INCREASE IN CALIFORNIA'S WIND GENERATION CAPACITY, 2010—2021, (IN GWH)

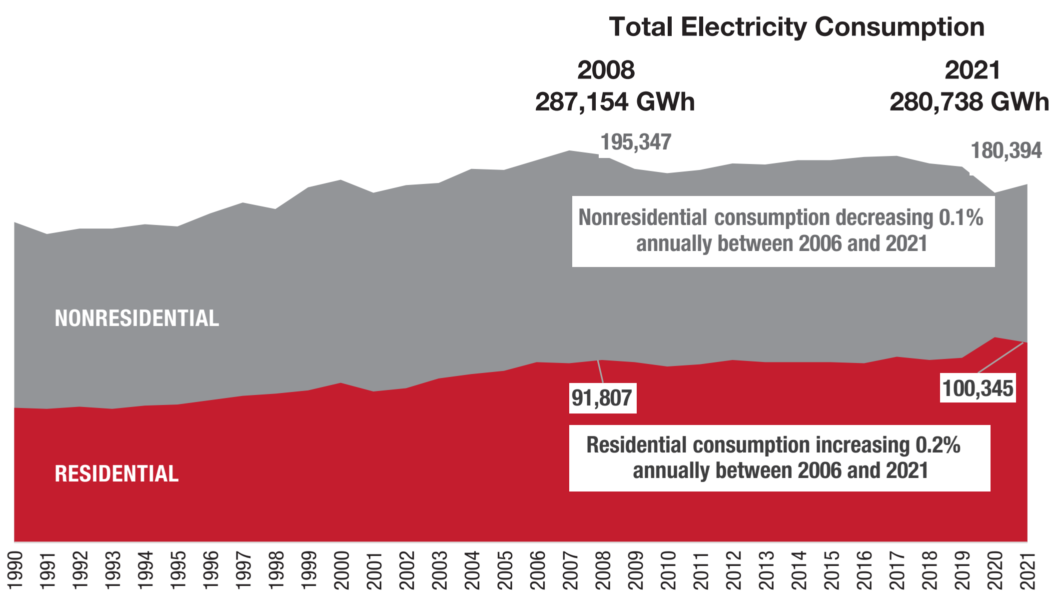


Source: Author calculations based on data from, http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

Due to the limitations of other prioritized alternative energy sources, the additional generation capacity of these sources must compensate for both the intended decreased capacity from the disfavored sources along with the increased demand created by the state's energy consumption mandates (i.e., electric vehicle sales mandates). The demand for electricity is estimated based on the historical consumption patterns adjusted for the mandated increase in EVs' share of new car sales. Figure 4 presents California's historical total electricity consumption between 1990 and 2021.

Figure 4 illustrates that the trend in electricity use changed around 2006. Prior to 2006 electricity consumption by both residential and nonresidential customers generally increased over time. For nonresidential users, electricity consumption in 2021 was below 2006 levels although the impact from COVID-19 is likely responsible for a large portion of this decline. Residential consumption has continued to increase, generally, although there is a similar consumption impact from COVID-19. Overall, total electricity consumption has been flat since 2008, although by 2021 electricity consumption is slightly lower.

FIGURE 4. TOTAL CALIFORNIA ELECTRICITY CONSUMPTION: RESIDENTIAL AND NONRESIDENTIAL, 1990—2021, (IN GWH)

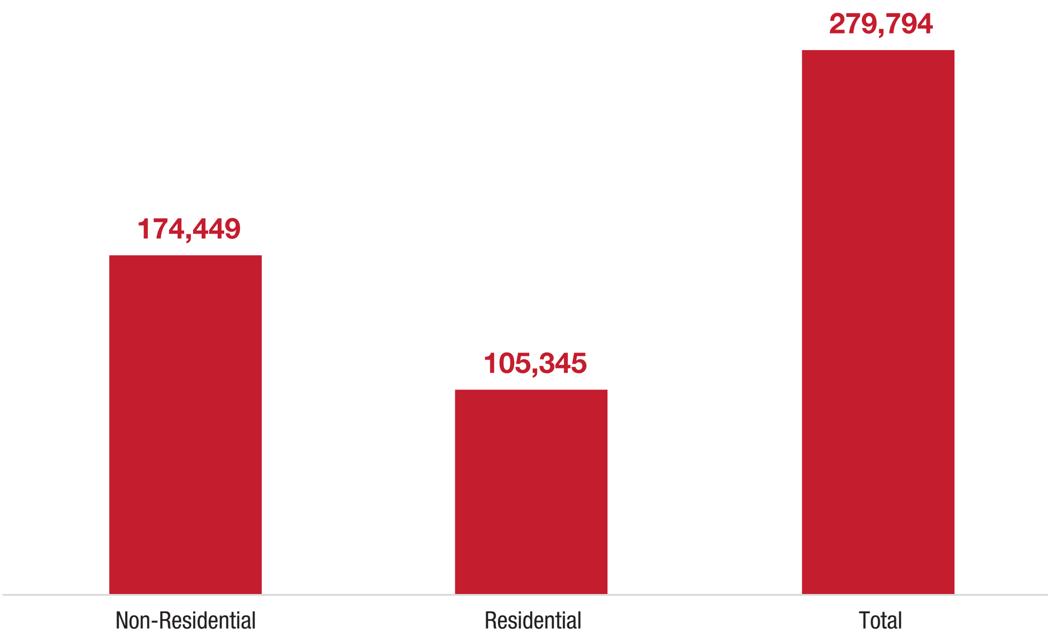


Source: http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

For conservative purposes, we assume that the average annual decline in nonresidential electricity consumption of 0.1 percent between 2006 and 2021 will persist through 2045. Similarly, the average annual increase in residential electricity consumption of 0.2 percent between 2006 and 2021 is assumed to persist through 2045. Since nonresidential customers consume significantly more electricity than residential customers, these projections imply overall electricity consumption—excluding the impacts from the current mandates that include prohibitions on selling nonelectric vehicles or natural gas appliances—will remain flat (280,738 GWh in 2021 compared to a projection of 279,794 GWh in 2045).

Figure 5 displays the projected electricity consumption breakdown, excluding the impact from the mandates, as of 2045. This assumption is conservative because, assuming California's economy continues to grow, maintaining a steady amount of electricity consumption requires both businesses and consumers to employ significant energy efficiency behaviors. Some of these behaviors, such as using energy efficient appliances, are required by current state mandates.

FIGURE 5. TOTAL CALIFORNIA ELECTRICITY CONSUMPTION BY 2045, PROJECTIONS BASED ON HISTORICAL CONSUMPTION GROWTH PATTERNS ONLY, (IN GWH)



Source: Author calculations based on data from, http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

The actual energy consumption in 2045 must also accommodate the state's mandates that residents must consume more products that rely on electricity rather than gasoline (i.e., electric vehicles) or natural gas (i.e., water heaters and furnaces). Accounting for just the impact from the current EV mandate, total future consumption will significantly exceed the generation capacity of the state based on the current technology mandates.

> **"Accounting for just the impact from the current EV mandate, total future consumption will significantly exceed the generation capacity of the state based on the current technology mandates."**

Table 1 provides our methodology for estimating total electricity needs if the current electric vehicle mandates are going to be met. Total electricity needs are estimated based on the current average charging requirements for an electric vehicle, which are 30 KWh per 100-mile range; the current average number of annual miles driven in California, which is 9,053; and the total estimated number of plug-in electric vehicles that will be on the road assuming that the current mandate schedule is adhered to and the number of new car purchases does not change due to the mandate.[15]

Based on the assumptions and calculations described in Table 1, by 2035 there will be 13.4 million EVs on California's roads, which is similar to *CalMatters'* estimate that there will be 12.5 million EVs by 2035.[16] Continuing through 2045, there will be 21.8 million EVs in the state. Charging all these EVs will require a 21-fold increase in the amount of electricity dedicated toward charging these vehicles from an estimated 2,753 GWh in 2022 to an estimated 59,283 GWh in 2045. Since the 2,753 GWh of electricity used to charge EVs in 2022 are already accounted for, meeting California's current EV mandates requires an additional 56,530 GWh of electricity over the current electricity consumption projections, see Figure 6.

TABLE 1
ESTIMATED ELECTRICITY REQUIREMENTS TO FULFILL CALIFORNIA CURRENT ELECTRIC VEHICLE SALES MANDATES
2021 - 2045

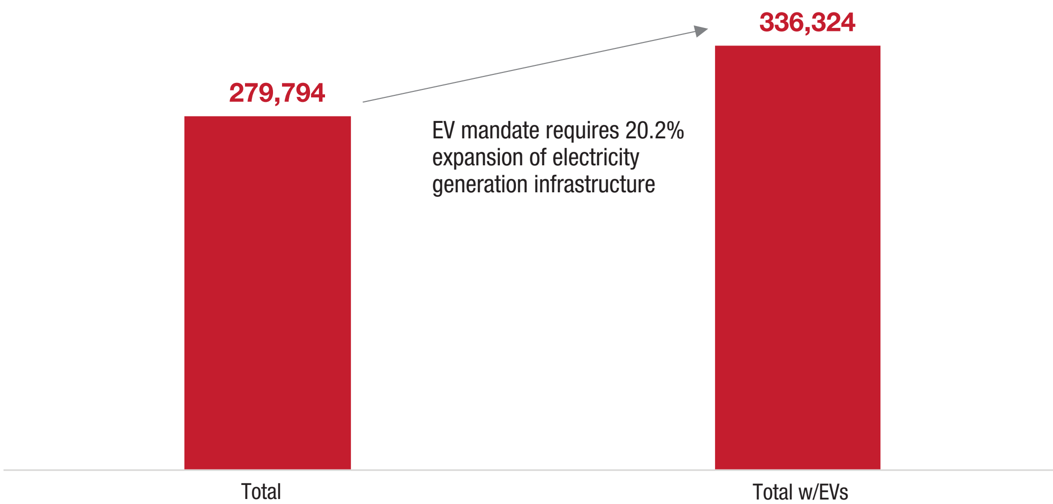
(1) Average EV Charge Requirements (kwh/mile)	0.3
(2) Average CA Miles Driven Per Year	9,053.0
(3) Annual Charge Requirements per EV	2,716.0

		EV Share (4)	# New Vehicle Registrations (5)	# of New EVs (millions) (6)	Total EV's/Plug-in BEVs on Road (millions) (7)	EV Electricity Requirements (GWh) (8)
ACTUALS	**2021**	**9.5%**	**1.860**	**0.176**	**0.828**	**2,248**
	2022	**17.1%**	**1.670**	**0.285**	**1.014**	**2,753**
PROJECTIONS	2023	21.6%	1.760	0.379	1.294	3,515
	2024	26.0%	1.783	0.464	1.659	4,506
	2025	30.5%	1.806	0.551	2.111	5,734
	2026	35.0%	1.830	0.640	2.653	7,204
	2027	43.0%	1.853	0.797	3.350	9,099
	2028	51.0%	1.877	0.957	4.209	11,430
	2029	59.5%	1.902	1.132	5.234	14,214
	2030	68.0%	1.927	1.310	6.442	17,496
	2031	74.4%	1.952	1.452	7.718	20,960
	2032	80.8%	1.977	1.597	9.030	24,524
	2033	87.2%	2.003	1.746	10.397	28,236
	2034	93.6%	2.029	1.899	11.831	32,133
	2035	100.0%	2.055	2.055	13.335	36,217
	2036	100.0%	2.082	2.082	14.777	40,132
	2037	100.0%	2.109	2.109	16.089	43,695
	2038	100.0%	2.136	2.136	17.267	46,897
	2039	100.0%	2.164	2.164	18.300	49,701
	2040	100.0%	2.192	2.192	19.182	52,096
	2041	100.0%	2.221	2.221	19.951	54,184
	2042	100.0%	2.250	2.250	20.603	55,955
	2043	100.0%	2.279	2.279	21.135	57,401
	2044	100.0%	2.308	2.308	21.545	58,514
	2045	100.0%	2.338	2.338	21.828	59,283

Sources and Calculations

(1) https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2020/01/09/electric-cars-will-challenge-state-power-grids#
(2) https://www.carinsurance.com/Articles/average-miles-driven-per-year-by-state.aspx
(3) (1) * (2)
(4) Projections based on EV share mandates with linear projections connecting legislatively established target dates.
(5) Projections based on 2008 - 2023 Registration CAGR: 1.3%
(6) Actuals based on: https://www.cncda.org/wp-content/uploads/Cal-Covering-4Q-22_FINAL.pdf; projections estimated as (4) * (5)
(7) Sum of (4) over time, accounting for a 15-year estimated lifespan for EV
(8) (3) * (7)

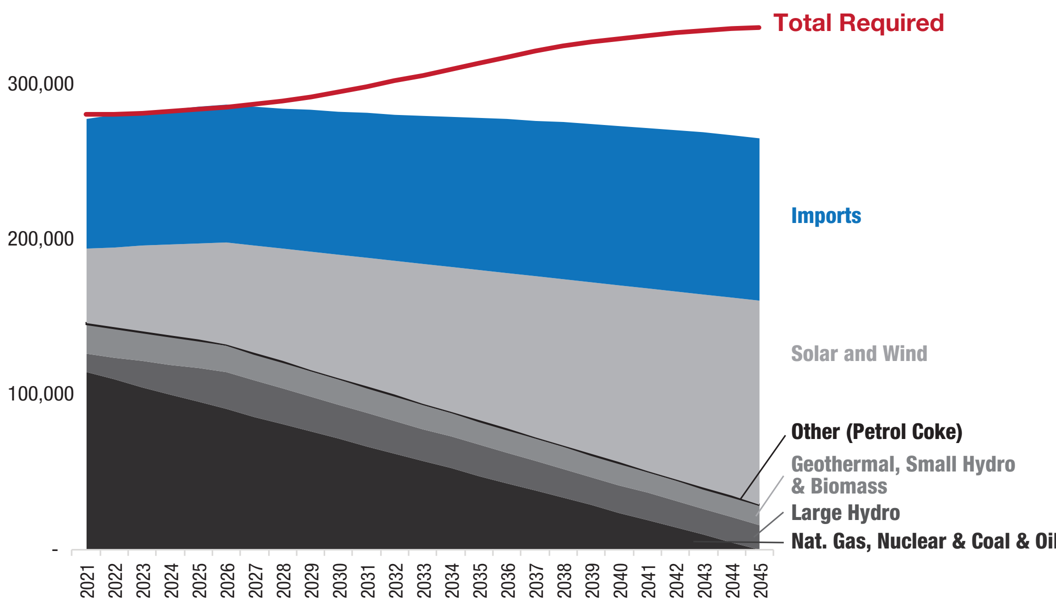
FIGURE 6. TOTAL CALIFORNIA ELECTRICITY CONSUMPTION BY 2045, PROJECTIONS BASED ON HISTORICAL CONSUMPTION GROWTH PATTERNS AND REQUIRED EV ELECTRICITY NEEDS (IN GWH)



Source: Author projections based on data from, http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

Using the results illustrated in Figure 6, the essential question asked in this section can now be refined: Is it reasonable to expect California to generate 336,324 GWh of electricity in 2045 based on its current alternative energy generation requirements? Figure 7 demonstrates that, based on current technologies, historical investment patterns, and only accounting for the energy needs of electric vehicles—the electricity needs from converting water heaters, stoves, and other appliances from natural gas to electricity are not considered—California's total generation capacity will quickly fall short of the state's total energy use. Importantly, these calculations do not account for the vital issue of matching generation to demand on an as-needed basis.

FIGURE 7. TOTAL PROJECTED GENERATION BY SOURCE BASED ON CALIFORNIA'S CURRENT POLICY ENVIRONMENT COMPARED TO PROJECTED ENERGY REQUIREMENTS BASED ON CURRENT POLICY ENVIRONMENT, 2021—2045



Source: Author projections based on data from, http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

The "Total Required" line in Figure 7 traces the estimated consumption pathway that leads to the electricity demand of 336,324 GWh in 2045. The shaded areas in Figure 7 represent the pathway for future generation based on current policies and the historical generation/investment patterns. Specifically,

- **Natural Gas, Nuclear, and Coal & Oil**: These resources generated 114,249 GWh of electricity in 2021. The last nuclear power plant in California (Diablo Canyon) under current law is scheduled to be shut down in 2030.[17] While nuclear power is considered zero emission and the plant could be extended, we assume that it will be shut down to portray the implications from retiring all disfavored generation sources. Natural gas, coal, and oil generation resources are mandated to be closed by 2045. While the actual pathway will vary and likely occur in large discrete reductions as different facilities are closed, we estimate the impact by eliminating a constant 4,760 GWh of generation capacity annually from the grid.

- **Large Hydro**: This renewable resource is often disfavored by environmentalists and is not officially listed as an approved alternative energy source. For the purposes of these calculations, we assume that California will keep these resources functioning. To the extent that the large hydro generation resources are closed, the generation gap will increase further. Figure 8 shows that the average annual output from California's large hydro generation has been declining slightly over time, approximately 412 GWh annually. Due to the unusually low output from large hydro in 2021, we assume that California's large hydro output grows to its 20-year average annual output of 23,604 GWh, which is achieved in 2026, and then declines by 412 GWh annually for the remainder of the forecast period.

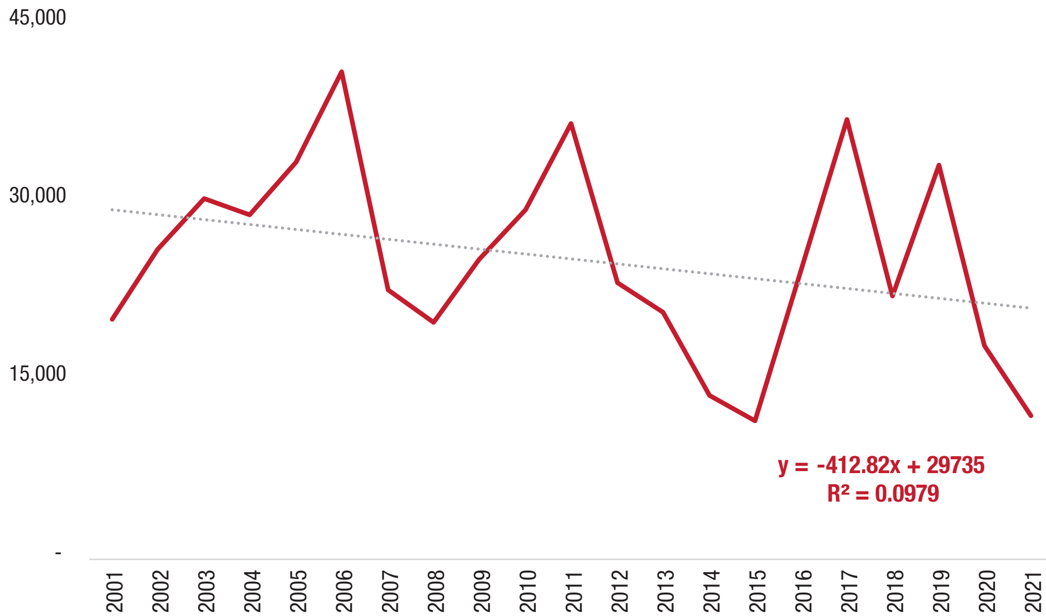
- **Geothermal, Small Hydro, and Biomass**: California's policy declares all three of these generation sources as "officially renewable." However, output of these resources has been declining over time as well, by 253 GWh annually on average, see Figure 9. We assume that the output from geothermal, small hydro, and biomass resources decline by this amount annually throughout the forecast period.

- **Other (Waste and Petrol Coke)**: Waste and petrol coke—a byproduct of petroleum refining, useful in the production of electrodes used in many appliations—are currently insignificant sources. While waste sources qualify as zero emission, petrol coke is fairly carbon intensive. Given the growth expectations for waste generation, we assume these resources will remain insignificant through 2045.

- **Solar and Wind**: Solar and wind (including offshore wind) are the intended workhorses of the revised generation infrastructure. Combined, as documented in Figures 2 and 3, California has been increasing its generation of these resources by 3,444 GWh annually, on average, since 2010. Since this pace reflects a time when policymakers have been encouraging greater reliance on these generation resources, we assume that the past is prologue. Total solar and wind generation capacity is assumed to increase by 3,444 GWh annually through 2045.

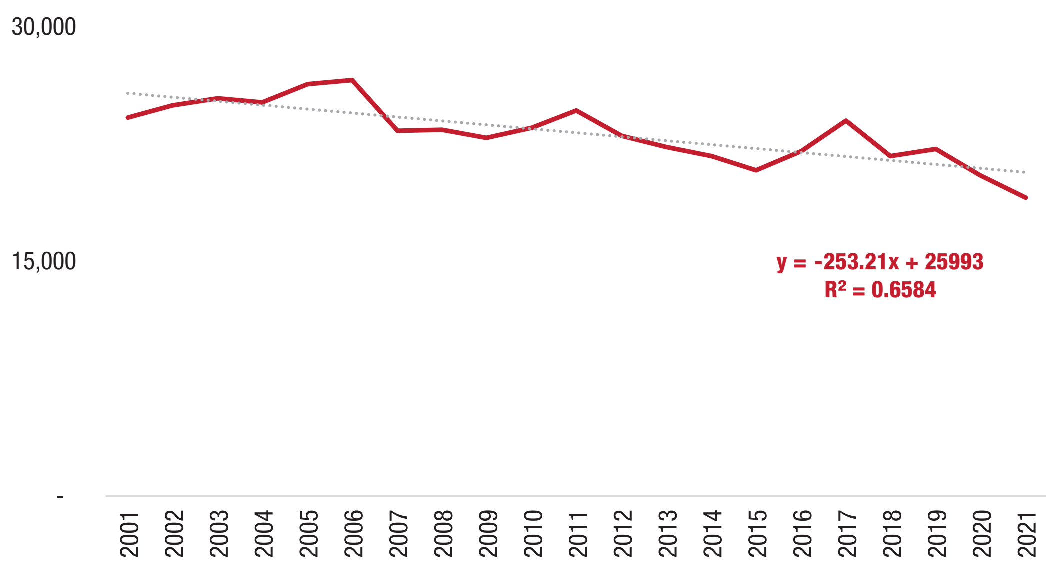
- **Imports**: Between 2010 and 2021, California imported 31.2 percent of its electricity from other states. In 2021, total electricity imports were slightly lower (30.1 percent). Not addressing issues of the feasibility of continuing to import such a large share of California's electricity needs or whether the generation sources of these imports are zero emissions or not, we assume that imports grow to their average rate over a five-year transition, and then remain 31.2 percent of total electricity used through 2045. This is a conservative assumption as these problems will exert downward pressure on the amount of zero emission electricity California will be able to import in the future.

FIGURE 8. CALIFORNIA LARGE HYDRO GENERATION (IN GWH) 2001—2021



Source: Author calculations based on data from http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

FIGURE 9. CALIFORNIA GEOTHERMAL, SMALL HYDRO, & BIOMASS GENERATION (IN GWH), 2001—2021



Source: Author calculations based on data from http://www.ecdms.energy.ca.gov/elecbycounty.aspx.

In Practice, Electricity Reliability and Adequacy Will Be Even Worse

As Figure 7 illustrates, it is doubtful that California will be able to generate sufficient electricity to meet future energy needs using only the favored generation sources; and it is not even close. Overall, total electricity generated will be 21.1 percent below the amount of electricity demanded—and this does not even account for the impacts from all the likely future mandates. Beyond the electric vehicle mandates evaluated above, officials are rapidly prohibiting connections for stoves, furnaces, hot water heaters, and dryers in new construction projects.

In September 2022, the CARB board approved a proposal that will ban sales by 2030 of new furnaces and water heaters powered by natural gas. The replacements will have to be zero-emission alternatives, such as electric heaters.[18] Increasing the stringency of the bans on natural gas use across the state will increase the stress on the transition to renewable energy to replace the lost sources of energy.

Consequently, these figures demonstrate that there are reasons to be exceptionally skeptical that California's current energy policy environment is achievable. Either the policies will cause extreme energy shortages and jeopardize quality of life or the state's political leaders will need to repeal the current suite of mandates.

There are many other concerns with California's approach that will undermine the reliability and affordability of California's energy system.

Wind and solar sources provide erratic service

Solar and wind power generation sources are non-dispatchable, which means that they cannot generate electricity on demand. These resources generate electricity when mother nature is ready to produce it and to the level that mother nature is willing to produce it.

Undoubtedly, sometimes mother nature is plentiful. News outlets reported in the middle of April 2022 that California was recently powered by nearly 100 percent renewable-sourced electricity. Gov. Newsom bragged that "a clean energy economy isn't some time far off in the future. We are doing it today." The state arrived at the 97 percent renewable energy mark at 3:39 p.m. on April 3, a week after it had achieved 96.4 percent coverage. Though they lasted only minutes, the new highs "solidly demonstrate the advances being made to reliably achieve California's clean energy goals," California Independent System Operator CEO Elliot Mainzer said.[19] On May 8, 2022, described as a sunny and windy day, enough renewable electricity was produced to meet 103 percent of consumer demand.[20]

The high marks of renewable energy generation did not last, of course, as Figure 1 vividly demonstrates. California remains dependent on natural gas and nuclear, despite the governor's crowing. Worse, what mother nature gives, she also takes away.

Nine months after California's fleeting experience with a fully "clean energy economy," wind power in Saskatchewan, Canada, produced -1 megawatt of energy. It was one of two days in which SaskPower windmills, all located in the southern portion of the province, produced negative energy. According to SaskPower, "The turbines were iced up and unable to produce. The -1 megawatt included the load to service the facilities."[21] California is just as susceptible to cloudy or windless days that will crash the energy produced from the alternative sources.

> **"California will also need to set aside vast tracts of land to dispose of the mountains of dead, no-longer-useful, environmentally lethal batteries that will accumulate over time."**

These extreme events embody the volatility and erratic nature of renewable energy and make designing a reliable grid difficult without the necessary battery infrastructure. Intermittent wind and solar power require sufficient storage to ensure that electricity is available without interruption. This necessitates the construction of enormous battery farms and further technological development of these battery resources. California will also need to set aside vast tracts of land to dispose of the mountains of dead, no-longer-useful, environmentally lethal batteries that will accumulate over time.

Battery technologies, however, are still severely limited relative to the required performance, raising serious doubts regarding the feasibility of installing the necessary battery resources to back up the solar/wind driven generation sources. A 2016 MIT and Argonne National Lab analysis study found "the marginal value of storage diminishes as more energy storage capacity is deployed."[22] In other words, doubling of the number of batteries won't double the output of available power.

As a storage medium for utility needs, batteries are limited by what have been called "time and cost" restrictions. "Fluctuating solar and wind power require lots of energy storage, and lithium-ion batteries seem like the obvious choice—but they are far too expensive to play a major role," says *MIT Technology Review*.[23] Estimated cost for each megawatt-hour stored is $700,000.[24]

Despite "growing optimism that these giant batteries will allow wind and solar power to displace a growing share of fossil-fuel plants," *MIT Technology Review* continues, "there's a problem with this rosy scenario."[25] Experts say lithium-ion batteries are far too costly and have short lives, therefore limiting their contribution to a green transition. If relied on "for massive amounts of storage as more renewable energy comes online—rather than turning to a broader mix of low-carbon sources like nuclear and natural gas with carbon capture technology—we could be headed down a dangerously unaffordable path," the MIT report acknowledges.[26]

> **"Experts say lithium-ion batteries are far too costly and have short lives, therefore limiting their contribution to a green transition."**

In the years that have passed since the MIT report was published in 2018, there have been no significant grid-scale battery technology breakthroughs, though there have been reports of long-duration storage being "at the cusp of a breakthrough," and "new types of iron-based batteries" possibly being "up to the task."

While lithium battery performance, as measured in energy stored per pound, has tripled since its introduction, the last decade has seen progress taper off and even lose ground when compared to gasoline. A battery weighing a half ton can move a car only the same distance that roughly 12 gallons of gasoline weighing 85 pounds will move an automobile. That's a sizable difference in energy density unlikely to be made up in manner timely enough to meet EV and renewable mandates.

While "advocates claim that 'energy tech' can conquer that gap, often analogizing with the progress of digital tech—computing's exponential growth," writes physicist and engineer Mark P. Mills, this "comparison isn't just flawed," it is in fact "impossible in the physics of energy."[27]

"If lithium chemistry could emulate digital progress since 1990," he writes, "an EV today would have a battery the size of a single flashlight C cell, not one weighing 1,000 pounds."[28] Simply put, developing an adequate battery infrastructure faces financial and physical limitations that raise serious questions regarding its future viability. Without the necessary battery infrastructure, solar and wind generation sources are too erratic and volatile to serve as the primary generation source for the state's electricity grid.

It is far from clear that the necessary generation infrastructure can be built

In practical application, rather than a bureaucrat's white board, there are many obstacles that will hinder the construction of the necessary alternative energy infrastructure as currently envisioned in Sacramento. To start, even though California is vast, land scarcity is actually a significant obstacle. Siting wind and industrial solar facilities must be based on the area's geological features—these resources must be built where mother nature is accommodating, not necessarily where the resources are needed or in a convenient location.

In addition to the logistical difficulties of building enough wind and solar power facilities to meet the coming demand is the problem created by NIMBYism. Examples of resistance to projects are visible all over the world. The 2022 midterm elections provided two fresh examples of the not-in-my-back-yard opposition. Voters in Crawford County, Ohio, rejected by a 3-to-1 margin a proposed 300-megawatt wind project. The vote upheld a 10-year ban on industrial wind development in the county. "The room erupted into cheers" when the results were read "to members of Crawford Neighbors United who had gathered at the Crawford County Courthouse."[29]

> **"Siting wind and industrial solar facilities must be based on the area's geological features—these resources must be built where mother nature is accommodating, not necessarily where the resources are needed or in a convenient location."**

The same election saw voters deliver "a crushing blow to plans for a 375-megawatt wind farm in mid-Michigan, where several local renewable energy ordinances were defeated across three townships and multiple officials were thrown from office for supporting the project," according to the local media.[30] Residents said the wind turbines are an "eyesore" and "a nuisance to the wildlife." A former California resident said she opposed the wind project because she had learned "about all the dangers with them—to nature, to the environment, even to our health," while "working for the National Parks."[31]

While California is considered a renewables-friendly state, it is not immune to NIMBYism. San Bernardino County, the largest geographically in California and as big as West Virginia, has banned construction of renewable energy sites in unincorporated parts of the county.[32] Los Angeles County has also prohibited wind turbines in some of its unincorporated areas.[33]

Kern County, California, Planning Director Lorelei Oviatt, who, according to RealClearInvestigations, "has turned her county into the top wind and solar producer in the state," says "the easy land" to install renewable energy generating-infrastructure "is gone," and that it's a "fantasy" to believe California can double its solar output to meet its target of 60 percent renewable energy by 2030 unless there are changes.

One particular hurdle is the need for tax revenues from new solar projects: They are not included in reassessments on land values.[34] "The tolerance of local governments and local communities for hosting is gone," says Oviatt. "They are closing fire stations and libraries. If you are serious about 60%, you have to look at the impact of solar on local government revenue."[35]

Wind and solar sources are neither zero emissions nor without adverse environmental and health impacts

Locating solar farms in hot, sunny deserts miles from the nearest development, such as the Mojave in California and Nevada, appears to be a reasonable strategy. But "the desert crust that binds soil—and absorbs carbon dioxide like a sponge—is disturbed when a solar farm is installed,"[36] making solar less appealing when the agenda is to cut carbon dioxide concentrations in the atmosphere.

Concern for wildlife is another obstacle for both wind and solar development. One nonprofit group, the Nevada-based Basin and Range Watch, has been a part of delaying and killing about a dozen renewable energy projects. Kevin Emmerich, a retired national park ranger who co-founded Basin and Range Watch and has lived in the Mojave Desert since the early 1990s, reckons that 70,000 acres of tortoise habitat in California have been destroyed in the rush to renewables. His group generated research that it used to pressure federal and local officials to reject desert projects. Between 2008 and 2016 the Bureau of

Land Management turned down as many as 93 solar developments in the desert due to environmental and military issues.[37]

"Why destroy pristine desert when you have many alternatives?" asks Emmerich. "There is huge potential to build solar on rooftops and degraded agricultural lands."[38]

The possibilities for rooftop solar, however, are not as encouraging as Emmerich suggests. While California has mandated that every new home built in the state, including condominiums and low-rise apartments, must have solar panels on their roofs, the policy clashes with a California Public Utilities Commission decision to end the incentives to install and use them in residential settings.

Solar takes large-volume bites of the land, an ancillary cost "that will become more apparent as time passes," writes veteran reporter John Murawski. "Solar energy facilities require vast stretches of land, converting farms and fields into geometric rows of indigo panels" in sunny regions. As farms and fields are converted, "little information is available on how these facilities are altering the landscape."[39]

> **"Solar takes large-volume bites of the land."**

The rapid buildout of solar, he continues, "exposes a moral paradox for the climate change movement." It turns out that "fighting global warming" requires deforestation and land clearing. Even though environmental activists point to efforts "to steer solar farms to disturbed land and rooftops," those options are often costly and impractical.[40]

"From New York to California, local opposition is thwarting wind and solar projects seen as essential to transitioning from fossil fuels," writes Vince Bielski in RealClearInvestigations, and "enough of them just can't stomach the outsize 'green' projects themselves—wind farms with 500-foot-tall turbines (around the height of the United Nations Secretariat Building) and solar spreads covering many square miles that forever change the idyllic look of rural communities and threaten pristine desert habitat." It's an opposition that "has been brewing for years and now poses a threat to states with plans to rapidly accelerate the buildout to meet ambitious renewable energy goals."[41]

There are no neighbors on the ocean to oppose wind turbines offshore. But rather than NIMBYism, offshore wind is likely to be opposed by BANANAism—build absolutely nothing anywhere near anything. While "little is known about the ecosystem response to wind wakes," the modeling indicates "that the associated wind wakes in the North Sea provoke large-scale changes in annual primary production with local changes of up to" roughly 10 percent. This happens "not only at the offshore wind farm clusters, but also distributed over a wider region."[42]

Furthermore, "the model also projects an increase in sediment carbon in deeper areas of the southern North Sea due to reduced current velocities and decreased dissolved oxygen inside an area with already low oxygen concentration." The researchers found evidence that "the structuring of coastal marine ecosystems on basin scales" could be substantially impacted by continued offshore wind farm developments.[43]

Plans call for offshore wind to generate 25 gigawatts of energy by 2045 (which would be one-fourth of the state's electrical power capacity, according to the transition blueprint), but as of April 2023, there are no offshore wind turbines in California. *MIT Technology Review* calls the plans "audacious" and predicts they will run up against "a daunting geological challenge." Just a few miles into the Pacific waters, the continental shelf drops sharply, making "it prohibitively expensive to erect standard offshore wind turbines which are set atop fixed structures that extend to the seafloor." When the water is that deep, turbines have to be built on floating platforms. But these floating turbines are not only "speculative," says MIT, the technology behind them is "very costly."[44] Almost all turbines off the California coast will be built this way, with 24 of the 25 gigawatts of planned offshore electricity projected to be produced from windmills floating on platforms.[45]

This "daunting geological challenge" will cause costs to rise to unaffordable levels. At $1.04 per megawatt hour, offshore wind has the most expensive "levelized cost of electricity and levelized cost of storage for new resources entering service in 2027," according to the U.S. Energy Information Administration. Battery storage is next at 64 cents per megawatt hour. All dispatchable sources are far cheaper, including nuclear, which would cost 61 cents per megawatt hour.[46]

"After their useful lives are ended, spent solar panels and wind turbines become an environmental hazard."

After their useful lives are ended, spent solar panels and wind turbines become an environmental hazard. As the U.S. Environmental Protection Agency (EPA) notes, "hazardous waste testing on solar panels in the marketplace has indicated that different varieties of solar panels have different metals present in the semiconductor and solder. Some of these metals, like lead and cadmium, are harmful to human health and the environment at high levels. If these metals are present in high enough quantities in the solar panels, solar panel waste could be a hazardous waste under (the Resource Conservation and Recovery Act)."[47]

From a health perspective, the National Center for Biotechnology Information says that exposure to wind turbine noise "does seem to increase the risk of annoyance and self-reported sleep disturbance in a dose-response relationship," and while "there seems to be a tolerable limit," higher limits set by legislation "may lead to increased numbers of annoyed subjects."[48]

French courts, meanwhile, have recognized "turbine syndrome" and ruled in favor of a couple who had complained that nearby windmills caused them "headaches, insomnia, heart irregularities, depression, dizziness, tinnitus and nausea for more than two years." Media reports said the couple believed the wind farm was the source of their ailments as the woodlands between their property and the nearest turbine was cut down. They said the noise was "comparable to a washing machine continually turning," and objected to the "white flashing lights" on the turbines.[49]

EVs create additional environmental and safety risks caused by battery fires that can be expansive and difficult to extinguish. Officials reported in early 2023 that the battery in a Tesla spontaneously burst into flames, causing a fire that required 6,000 gallons of water to put out,[50] about half the amount needed to fill a 12-foot-by-24-foot backyard pool six feet deep.[51] In another EV fire, more than 20,000 gallons of water were used by firefighters before the blaze was extinguished.[52] Additional tankers from other fire departments sometimes have to be called in to finish a job that can take hours.[53] EV battery fires are considered rare events, but when they do occur, they consume voluminous resources because they burn hotter and longer than the fires from internal combustion engine cars, which can be extinguished with about 500 gallons of water.[54]

"EVs create additional environmental and safety risks caused by battery fires that can be expansive and difficult to extinguish."

An industrial-scale battery fire presents another set of challenges. A fire in September 2022 at the Pacific Gas & Electric's Moss Landing energy storage site, which had opened only months earlier, was limited to a single-battery pack. Yet the damage to the system, which was designed, constructed, and maintained by both PG&E and Tesla,[55] was estimated to be around $50,000.[56] A fire three years earlier in Surprise, Arizona, was reported to be "an extensive cascading thermal runaway event, initiated by an internal cell failure within one battery cell." An April 2022 fire at an energy storage facility in Chandler, Arizona, is under investigation to determine its cause. At least one Arizona regulator is asking questions and has said that the types of lithium-ion chemistries used in batteries at storage facilities "are not prudent and create unacceptable risks."[57]

Battery fires have occurred in other countries, as well, with more than three dozen reported from 2018 to 2021, and one taking the lives of two firefighters.[58]

The Moss Landing fire burned out after five hours, but it continued to smolder, fueling concerns the lithium-ion batteries might be releasing toxins into the air, according to the *Santa Cruz Sentinel*. "Lithium-ion battery fires are notoriously hard to extinguish because they burn at extremely high temperatures and produce dangerous fumes," and in this case required a shelter-in-place order in the surrounding area, shutting down businesses.[59]

"The fire's out," the *Sentinel* editorialized, "but the incident raises questions about California's electric grid and the drive to move away from fossil fuels to combat climate change." The incident provided "a reminder that battery blazes are becoming increasingly common and destructive—and safety measures, including fire drills, for residents around storage facilities will have to be put in place and widely disseminated."[60]

Based on the current state of the industry, the 100 percent electric vehicle mandate is unachievable

The governor's executive order, codified by CARB in September 2022, assumes that the manufacturers can meet the state's artificially imposed market mandate. The people who will have to make these mandates a reality (e.g., those who would know) are not as confident. Akio Toyoda, former president and CEO, and now chairman of the Toyota Motor Corporation, says there is a "silent majority" in the industry that "is wondering whether EVs are really OK to have as a single option. But they think it's the trend so they can't speak out loudly." The *Wall Street Journal* reports that "Toyoda's long-held skepticism about a fully electric future has been shared by others in the Japanese car industry, as well."[61] Toyota Chief Scientist Gill Pratt has been critical of the "happy talk" in the industry regarding the future of EVs. "What has to change is that we have to mature a little bit, and we have to stop doing wishful thinking. A real discussion is that these are the constraints in the development of resources in the world, both material resources and charging infrastructure and renewable power … If that is true, how do we reduce the total amount of carbon dioxide that will accumulate? That is a mature discussion, not a kind of dream discussion."[62]

Bearing out these concerns, car makers, until recently, had doubts that there would be enough customers for their EV models. But "now, they worry they can't build them fast enough, while they intensify a multibillion-dollar rush to accelerate timelines and bring factories online," writes the *Wall Street Journal*. The industry has been "flat-footed," and not ready for the increased demand that's been fueled in part by federal and state tax breaks (and a mandate in the largest state in the country).[63]

Catching up will require more than condensing timelines and adding factory capacity. The scarcity of raw materials necessary to manufacture EVs is cause for concern. The lithium batteries that are commonly used in electric automobiles "depend on five critical minerals whose domestic supply is potentially at risk for disruption: lithium, cobalt, manganese, nickel, and graphite," says the Congressional Research Service. While some lithium, cobalt, and nickel, are mined in the U.S., there is no domestic mining for manganese or graphite.[64] Carlos Tavares, CEO of Stellantis, the world's fourth-largest automaker, has warned of an upcoming shortage of EV batteries. He expects they will be in short supply by 2024-2025, with a dearth of raw materials to follow. Delays caused by scarcity "will slow availability and adoption of EVs by 2027-2028," CNBC reported in 2022.[65]

During the summer of 2022, the media reported about "a key component" of electric vehicles—graphite—"hurtling" toward "a tipping point when global demand will outstrip supply."[66] That was followed by reports of "scarce parts"[67] and "questions around the viable amount of raw materials available for EV batteries."[68]

Hand in hand with the shortages is the fact that the raw materials are available in only a few countries. Some of them are unstable and therefore unpredictable, and one, China, uses its dominance over technology metals as a geostrategic tool, or weapon.[69] Nearly half of all world cobalt reserves are found in the Democratic Republic of the Congo, according to the United Nations, while Chile has 58 percent of lithium reserves, China, Brazil and Turkey hold 80 percent of natural graphite reserves, and 75 percent of manganese comes from Australia, Brazil, South Africa and Ukraine.[70]

There has been reason for some optimism of late, such as a recent discovery of a rare earth mineral deposit in Sweden, the largest known deposit in Europe. "It could become a significant building block for producing the critical raw materials that are absolutely crucial to enable the green transition. We face a supply problem. Without mines, there can be no electric vehicles," said Jan Moström, president and CEO of LKAB, which operates mines in the country. However, Moström had to admit that "it will be at least 10-15 years before we can actually begin mining and deliver raw materials to the market."[71] Energy author and journalist Robert Bryce believes Sweden's "rare earths won't dent China's monopoly for decades," in part because once mined, "the materials will then have to be processed and turned into magnets," which are used in both EVs and wind turbines.[72]

> **"Domestically, mining could help bring more raw materials to market, but the same groups and policymakers that hope to force EVs on the country also oppose mining for those metals in the United States."**

Domestically, mining could help bring more raw materials to market, but the same groups and policymakers that hope to force EVs on the country also oppose mining for those metals in the United States. The Duluth Complex in Minnesota could be an important source, as it holds "one of the world's largest undeveloped mineral deposits, including copper, nickel and cobalt, that are needed in vast quantities for EV batteries," writes the *Wall Street Journal*. Yet the Biden administration is blocking more than 225,000 acres in the Superior National Forest, where the Duluth Complex is located, from mining for two decades. "Other mining projects in Minnesota, Arizona, Nevada and Alaska have been stuck in permitting purgatory and the courts," writes the *Journal*.[73]

Long before the political campaign pushing EVs, it was widely thought that the world would run out of fossil fuels. But it's more likely that the earth will not be able to provide the raw materials needed to transition away from carbon-based energy.

Electric vehicle use threatens to crash the grid

Due to the typical use of EVs, Stanford engineers have warned that "electric car charging could crash a grid powered by renewable energy," according to one media outlet's coverage of a university report.[74] "Most EV owners currently charge their vehicles at night, but that could be a problem in the next decade when more EVs are on the road and the grid is increasingly based on wind and solar. EVs require a lot of energy to charge, and solar energy production falls off at night." Consequently, utilities will have to "rely on fossil-fuel peaking plants or a lot of grid storage to supply power."[75] Of course, if California's policies are implemented as intended, there will be no fossil-fuel peaking plants to back up the grid. The result will be electricity shortages.

The report's authors suggest that EV owners do their charging during the day to avoid straining the grid's capacity. "We encourage policymakers to consider utility rates that encourage day charging and incentivize investment in charging infrastructure to shift drivers from home to work for charging," said Ram Rajagopal, an associate professor of civil and environmental engineering at Stanford, and the study's co-senior author.[76] But this not only does nothing to alleviate the shortages caused by the transition to renewable energy (even though there can be instances of excess solar energy during daylight hours), it highlights the deficit. It also reverses gains in modern convenience made possible by natural gas, coal, and nuclear power generation.

Neither does it seem to take into consideration the authors' own findings that the current charging of EVs is already causing problems. Well more than a decade before the 2035 deadline, "uncontrolled charging," meaning that EV owners are free to charge whenever they wish to without penalties or incentives affecting their choices, "has been shown to increase peak demand and cause transformer overloading, force early replacement of equipment, overload transmission lines, worsen power quality or require substation upgrades."[77] Again, the researchers suggest "controlled charging," which does nothing to increase capacity to meet the growing demand.

To ensure that owners charge at the "correct" times, officials are using coercion. The local utility in Concord, Massachusetts, for instance, has asked customers to participate in a program that limits charging electric vehicles to between 10 p.m. and noon. Participants must "agree to release their electric meter or electric vehicle charger data, where available, for the purposes of the program." Owners of all-electric vehicles receive a $10 monthly credit, while plug-in hybrid owners receive $5 monthly.[78]

As an attempt to help alleviate this problem, Senator Nancy Skinner (D-Berkeley) has proposed Senate Bill 233 that would mandate that new EVs must contain bidirectional charging capability starting in 2027.[79] While this proposal marginally adds charging options for the grid, there are many downsides, as well. Bidirectional charging technology increases the cost of EVs, creates additional costs for homes and businesses that may need to upgrade their infrastructure to accommodate the technology, and further substitutes Sacramento's values for consumers.

The proposed policies impose exceptionally large costs on Californians

Reworking California's electricity and energy infrastructure will require a tremendous amount of money. Transforming the energy system will impose costs that will have to be met over the next 20 years, in good budget times and in bad. It will require a commitment to funding these programs regardless of other budget priorities, such as the costs that the state's large unfunded pension crisis will be imposing. For example, CAISO's "cost estimate of transmission development to integrate resources of SB100" is $30.5 billion.[80]

Chris Shimoda, California Trucking Association senior vice president of government affairs, said the state "has a huge task on its hands to accommodate its electrification goals," that the charging infrastructure "is nearly non-existent," and by the California Air Resources Board's own estimates, "we need to be putting in more than 300 chargers a week between now and 2035 to support their proposed regulation, including nearly 10MW of public charging each week."[81]

There are only about 80,000 charging stations in public spaces across the state, fewer than one-third of the 250,000 that are supposed to be available by 2025.[82] The cost of each standard Level 2 charger is $7,000 to $11,000; fast-charging units can cost from $100,000 to $120,000 each.[83]

But installation is only part of the equation. Once chargers are in place, they must be maintained, which is no easy task. A study released in early 2022 found that "27 percent of all EV charging stations in the San Francisco Bay Area" were "non-functioning." In most of those, the causes were unresponsive connectors, unavailable screens, payment systems malfunctions, charge initiation and network failures, or broken connectors. Other failures include cables being too short to reach cars' charging ports.[84]

A few months before, a California Air Resources Board survey noted that 44 percent of EV drivers had experienced difficulties at charging stations "and considered operability and payment major issues to charging."[85] Most EV owners—nine in 10—are satisfied with their cars, but according to a survey by the Los Angeles-based Plug In America, they are frustrated with the public charging infrastructure, "the most common issues being 'broken or nonfunctional chargers' or 'too few charging locations.'" More than a third of respondents said "this is at least a 'moderate concern.'" Drivers also griped about the long distances between charging locations, slow charging speeds and costs.[86]

Charging has become such a complication in one Melbourne, Australia, suburb that an "EV crew" of residents came up with what its "members" call a "Roster Rotation" that would "enable the charging of our EVs." The group suggests a "roster" of charging days and times and asks that during these periods non-EV-owning residents "ration your electricity use." Air conditioners, washers, dryers, and other large appliance should be "off when we are charging our cars." They are asking for this "small sacrifice" to "help put an end to global warming and the associated issues." When the notice was sent, there were four EVs on the street, the fourth having just been added.[87] These types of rigid charging schedules and severe use restrictions will inevitably be required in California for the state to keep the lights on.

"Before the power can ever be used in chargers, it must move across the grid. But the grid needs to be extensively expanded and investments are lagging."

Before the power can ever be used in chargers, it must move across the grid. But the grid needs to be extensively expanded and investments are lagging. David Victor, a professor and co-director of the Deep Decarbonization Initiative at the University of California, San Diego says expansion of the grid is going to have to come "at a radically much faster rate." He believes it is "plausible" to build it fast enough, but only "if the right policies are in place." "It's not guaranteed," he said. "It's best-case."[88]

The California Independent System Operator 2022-23 transmission plan draft outlines "new transmission infrastructure needed to reliably and efficiently meet California's clean-energy objectives over the next decade," identifies "additional transmission and resource capacity" and recommends "46 transmission projects costing an estimated $9.3 billion."[89]

At that price, it's obvious why "hardly anybody wants to pay for them."[90] Even if the finances were set, the NIMBYs and BANANAs would obstruct progress. Connecting renewable energy sources to customers requires new lines to be strung across long distances, taking up vast amounts of land.

Building adequate transmission will be a heavy lift, as well. The National Renewable Energy Laboratory estimates the U.S. would have to double the size of its transmission grid to be able to generate just 90 percent of the country's electricity from renewable sources.

"At current growth rates," says energy author and journalist Robert Bryce, that would "only take about 140 years!" Extending the grid by just 60 percent would take 84 years.[91] It's likely California will need far more than a 60 percent expansion, possibly even more than a doubling to reach its target. The *Sacramento Bee* reported in December 2022 that "several agencies project the [California] grid will need to roughly triple its transmission capacity by 2050."[92]

For every EV that's on the road in 2030, utilities will have to invest between $1,700 and $5,800 to pay for grid upgrades. The costs will ultimately be passed on to ratepayers. There's no way to avoid this. Upward pressure on prices will grow as EV adoption rises, "because investment costs increase exponentially as penetration increases, given the need for more expensive equipment and a larger number of new assets," says Boston Consulting Group.[93] Upgrading the grid will also require a scale of effort hardly ever seen before in human history. In testimony before the U.S. House Select Committee on the Climate, Mark Mills noted:

> Building and installing enough hardware to replace all of America's conventional gas- and coal-fueled electric power plants by, say, 2040 would require a continuous grid construction program several hundred percent greater than occurred during any single peak year of grid construction over the past half-century. Such an endeavor would be, quite literally, an industrial effort comparable to a World War II level of mobilization. And it wouldn't be possible without clearing away regulatory delays, something that is not now being proposed anywhere.[94]

In California, it must be noted, the political climate makes "clearing away regulatory delays" a particularly onerous task.

Recommendations

Considering these obstacles, California's policymakers should rethink its global climate change strategy. The state has been down this path before and couldn't meet its ambitions. California Gov. Arnold Schwarzenegger signed an executive order in 2004 that instructed state agencies to build by 2010 a network of hydrogen fueling stations along state highways. "It never happened," Jonathan Lesser writes in *City Journal*. As of January 2023, there were only 53 operative stations, most around the Bay Area and Los Angeles, while there were roughly 10,000 hydrogen-fuel cell vehicles thirsty for fuel.[95]

Learning from this experience, California should repeal its current array of global climate change production and consumption mandates. In their stead, the state should promote a market-based approach to global climate change. This approach recognizes that there are many potential paths to a lower-emission future. Instead of relying on a few hundred policymakers who want to design the future, policies should embrace technologies that are efficient today and empower the millions of Californians to both manage their current energy use and design the innovations that will ultimately secure an affordable lower-emission energy system.

For the foreseeable future, nuclear generation remains an essential low-emission, affordable generator of electricity. Unfortunately, rather than embracing innovations to improve this sector, atomic energy is being phased out in California. The lone nuclear power facility remaining in the state is the Diablo Canyon plant located in San Luis Obispo County and is scheduled to be shut down in 2030 after legislation was passed to keep it open beyond 2025, the year regulators were initially planning to close it. California's program of nuclear power retirement is in line with the desires of most green advocates and climate activists. But not all. A "revival" of nuclear energy, though still nascent, is real. "In recent years, some eco-pragmatists and climate scientists have begun touting the advantages of zero-carbon nuclear energy," says energy journalist James B. Meigs.[96]

While California, in keeping with its serial prohibitions, is still intent on banning nuclear power, both parties in Washington support nuclear energy innovation and modernization.[97] The International Energy Agency has declared that "nuclear power is making a comeback—and in a strong fashion."[98] Here in California, researchers have announced that if Diablo Canyon's "operating license was extended until 2035, it would cut carbon emissions by an average of 7 million metric tons a year—a more than 11 percent reduction from 2017 levels—and save ratepayers $2.6 billion in power system costs."[99] That team of researchers also noted that "further delaying the retirement of Diablo to 2045 would spare 90,000 acres of land that would need to be dedicated to renewable energy production to replace the facility's capacity, and it would save ratepayers up to $21 billion in power system costs."[100]

Simply put, without nuclear power, the likelihood of California reaching its emission targets while also turning over the automobile fleet from gas-powered cars to EVs is low. The opposition to nuclear power is unwarranted. It is a safe (of all energy sources only solar is safer in terms of fatalities and the difference is negligible[101]), reliable (it can generate electricity on demand), and green (its greenhouse gas emissions are lower than all sources of energy[102]). Initial costs of nuclear energy are high because plants are expensive to build, but they are relatively inexpensive to operate, even when factoring in waste disposal and decommissioning costs. In some instances, nuclear energy is economically competitive with natural gas and coal in producing electricity.[103]

> **"Simply put, without nuclear power, the likelihood of California reaching its emission targets while also turning over the automobile fleet from gas-powered cars to EVs is low."**

Advances in technology, however, promise to bring down the high costs of construction. When combined, they have the potential to reduce the cost of building new reactors by more than a tenth.

"These technologies can be applied to a variety of advanced reactor designs," says Ashley Finan, director of the Energy Department's National Reactor Innovation Center. "If we can help make them available to reactor developers by the 2030s, we can ultimately help improve the economics of deploying advanced reactors."[104]

Using "vertical shaft construction" to build reactors can save as much as "$50 million in project costs for a typical nuclear plant that requires one million cubic yards of excavation," says Finan, while also "significantly" reducing construction schedules. The technique "leverages best practices from the tunneling industry and others to reduce the amount of excavation and need for engineered backfill after the structure is constructed."[105]

On-site labor during construction can also be reduced by using "steel-concrete composites," which are a "possible option to build the major structural components of" nuclear facilities. These composites allow much of the work to be done in factories, which then ship the completed sections to sites for quick assembly. The parts also improve safety, as they "better meet certain corrosion requirements," says Finan, who in her capacity as director of the NRIC has knowledge of innovations that are "going to transform the nuclear energy industry without even splitting a single atom."[106]

A bill introduced in the California Assembly in December 2022 would exempt small modular nuclear reactors from the state's existing law, which "prohibits the State Energy Resources Conservation and Development Commission (Energy Commission) from certifying a nuclear fission thermal powerplant." The modular reactors could have up to 300 megawatts per unit of electrical generating capacity. The bipartisan legislation, Assembly Bill 65, would also require the Public Utilities Commission "on or before January 1, 2026, to adopt a plan to increase the procurement of electricity generated from nuclear facilities and to phase out the procurement of electricity generated from natural gas facilities."[107] The bill failed in its first committee vote in April 2023.

> **"The power density of new small modular reactors built by Rolls-Royce means they require one-10,000th of the land required for a wind farm and about one-1,000th of the land needed for a solar project."**

Modular nuclear power units hold some promise. They are cheaper and built faster than traditional nuclear plants. They're small enough to be shipped from the factory by container and then quickly installed on site. The power density of new small modular reactors built by Rolls-Royce means they require one-10,000th of the land required for a wind farm and about one-1,000th of the land needed for a solar project.[108]

As impressive as these new generation reactors are, sustainably addressing global climate change while maintaining energy affordability ultimately requires continued innovation.

While state government is not well positioned to drive these innovations, policymakers still have an important role to play in establishing an environment that harnesses the knowledge of millions of Californians who have the know-how and inclination to tackle the problem.

Establishing a pro-emission reduction innovation environment requires reforming overly burdensome regulations such as the California Environmental Quality Act (CEQA). CEQA "now includes over 190 code sections and 250 implementing regulations (called 'CEQA Guidelines') with 14 appendices. As the number of CEQA provisions has expanded, so too has its reach. CEQA is now a major component of the planning and approval process for almost every public and private project in California."[109] CEQA notoriously increases the costs for construction projects from housing to transportation.[110] It also obstructs the development of low-emission generation technologies when petitioners file,

> lawsuits to leverage settlements as developers fold in order to avoid expensive, and potentially fatal, project delays. These CEQA lawsuits, when combined with California's extensive land use and permitting laws, help explain why it costs between 15 to 20 percent more to construct wind projects in California than in other areas of the country.
>
> One example of this CEQA abuse involved two environmental nonprofits that, between 2012 and 2015, filed over eight lawsuits challenging various wind and solar projects in San Diego and Imperial counties. None of these lawsuits resulted in any of the challenged projects being modified to lessen environmental impacts, let alone scrapped. Instead, the petitioners received massive settlements—over $17.2 million in total. And, in those rare instances where the developer didn't settle, the lawsuits were usually rejected by the courts.[111]

Reforming CEQA, or at least capping these notoriously burdensome costs and delays for nuclear power plants and other low emission technologies will help accelerate the deployment of affordable lower-emission energy technologies.

It is also important to recognize the importance of innovations in wind and solar generation. These resources have made great technological strides but are still limited and have significant downsides. Electric vehicles remain unaffordable for most Californians and have significant use limitations. Innovative new technologies are required, consequently, if widespread adoption of lower-emission technologies is to occur.

Empowering individuals to both develop and judge the efficacy of these technologies is the most efficient way to overcome these technological constraints. California can encourage these efforts through policies such as technologically neutral tax incentives and capital expensing that lowers the costs and/or increases the returns from developing economically efficient low emission technologies.

Conclusion

It is clear by any objective measure that California is relying more on hope than a workable plan to transition to a green power grid. Not only is the technology far behind policymakers' ambitions, the resistance to infrastructure development that is needed to sharply increase renewable energy generation is not insignificant. Other seemingly insurmountable hurdles include insufficient battery advancements, environmental resistance to the buildout of wind and solar farms, the negative environmental impacts of renewable energy, the scarcity of materials required to sufficiently expand wind and solar energy, and the structural difficulties of building large-scale public projects in California.

The enormous costs also present a stubborn barrier, especially as California is going to rely on offshore wind for a full 25 percent of its electricity by 2045. It is by far the most expensive option.

Perhaps the highest hurdle is the EV mandate. With projections that there will be more than 13 million EVs by 2035, and many more by the 2045 targeted date for a fully green grid, it would be stunning if electricity demand did not outstrip supply. Keeping those vehicles charged and on the road will require a 21-fold increase in the amount of electricity dedicated toward charging these vehicles from an estimated 2,753 GWh in 2022 to an estimated 59,283 GWh in 2045. Even as policymakers go forward with plans, Stanford engineers have warned that EV "charging could crash a grid powered by renewable energy." The state could resort to backup energy from conventional sources, such as natural gas plants, but in doing so will violate its own terms of the transition.

California policymakers made an enormous mistake in their haste to push technologies that aren't ready and in creating programs that will likely suffer the same frustrating delays and roadblocks the state's high-speed rail project has experienced. It is past time for the state to reassess its approach for addressing global climate change.

Endnotes

1 Author calculations based on data from the Energy Information Administration, Table 1. State energy-related carbon dioxide emissions by year (1970—2020).

2 California Legislative Information https://leginfo.legislature.ca.gov/faces/billCompareClient.xhtml?bill_id=201720180SB100&showamends=false

3 "CARB approves unprecedented climate action plan to shift world's 4th largest economy from fossil fuels to clean and renewable energy," California Air Resources Board, December 15, 2022 https://ww2.arb.ca.gov/news/carb-approves-unprecedented-climate-action-plan-shift-worlds-4th-largest-economy-fossil-fuels

4 Executive Order N-79-29, Executive Department State of California, https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.

5 "California Enacts World-Leading Plan to Achieve 100 Percent Zero-Emission Vehicles by 2035, Cut Pollution," Office of Governor Gavin Newsom, August 25, 2022 https://www.gov.ca.gov/2022/08/25/california-enacts-world-leading-plan-to-achieve-100-percent-zero-emission-vehicles-by-2035-cut-pollution/#:~:text=%E2%80%9CThis%20plan's%20yearly%20targets%20%E2%80%93%2035,won't%20pollute%20our%20communities

6 "CARB Accelerates ZEV-Only Truck Sales To 2036, But Resists Fleet Change," *Inside EPA's Climate EXTRA*, February 22, 2023 https://insideepa.com/climate-news/carb-accelerates-zev-only-truck-sales-2036-resists-fleet-change

7 Robert Levicoff, "The Beginning of the End of the Internal Combustion Engine? California to Phase Out Gas-Powered Vehicles by 2035," JD Supra, September 22, 2022 https://www.jdsupra.com/legalnews/the-beginning-of-the-end-of-the-9926196/#_ftnref1

8 Senate Rules Committee, Office of Senate Floor Analyses, https://leginfo.legislature.ca.gov/faces/billAnalysisClient.xhtml?bill_id=201720180SB100#

9 "2021 Total System Electric Generation" California Energy Commission, https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2021-total-system-electric-generation. (Accessed April 19, 2023)

10 "20-Year Transmission Outlook," California Independent System Operator, January 31, 2022 http://www.caiso.com/InitiativeDocuments/Draft20-YearTransmissionOutlook.pdf

11 J Temple “The $2.5 trillion reason we can’t rely on batteries to clean up the grid” *MIT Technology Review*, July 27, 2018, https://www.technologyreview.com/2018/07/27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/.

12 Ibid.

13 K Balaraman “Why is the utility industry less bullish on grid-scale storage?” *Utility Dive*, February 13, 2020. (emphasis added)

14 Garrett HeringSusan Dlin “‘We’re in a perpetual short’: US energy storage CEOs face limits of growth” *S&P Global Market Intelligence*, December 30, 2022, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/we-re-in-a-perpetual-short-us-energy-storage-ceos-face-limits-of-growth-73497347.

15 See Table 2 for exact sources and calculations.

16 Nadia Lopex, “Race to zero: Can California’s power grid handle a 15-fold increase in electric cars?” *CalMatters*, January 17, 2023 https://calmatters.org/environment/2023/01/california-electric-cars-grid/

17 Nadia Lopez “Feds allow Diablo Canyon to stay open while seeking 20-year extension” *Cal Matters* March 2, 2023 https://calmatters.org/environment/2023/03/diablo-canyon-nuclear-power-plant/. The utility is seeking to keep the plant operating for an additional 20 years, which has not been approved as of this writing.

18 Caleigh Wells, “California plans to phase out new gas heaters by 2030,” National Public Radio, September 23, 2022 https://www.npr.org/2022/09/23/1124511549/california-plans-to-phase-out-new-gas-heaters-by-2030

19 David Knowles,“California sets clean energy as it pushes toward climate change goals,” *Yahoo! News*, April 18, 2022 https://news.yahoo.com/california-sets-clean-energy-record-as-it-pushes-toward-climate-change-goals-182301261.html

20 Lauren Sommer, “California just ran on 100% renewable energy, but fossil fuels aren’t fading away yet,” National Public Radio, May 13, 2022 https://www.npr.org/2022/05/07/1097376890/for-a-brief-moment-calif-fully-powered-itself-with-renewable-energy

21 Brian Zinchuk, “For four days in a row, Saskatchewan gets next to no power from wind turbines. Two days saw negative power production,” *Pipeline Online* https://pipelineonline.ca/for-four-days-in-a-row-saskatchewan-gets-next-to-no-power-from-wind-turbines-two-days-saw-negative-power-production/#/?playlistId=0&videoId=0

22 Fernando J. de Sisternes, Jesse D. Jenkins, Audun Botterud, “The value of energy storage in decarbonizing the electricity sector,” *Applied Energy*, Volume 175, Pages 368-379, Argonne National Laboratory; MIT Energy Initiative, Massachusetts Institute of Technology, August 2016 https://www.sciencedirect.com/journal/applied-energy/vol/175/suppl/C

23 James Temple, “The $2.5 trillion reason we can’t rely on batteries to clean up the grid,” *MIT Technology Review*, July 27, 2018 https://www.technologyreview.com/2018/07/27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/

24 David Wojick, “Astronomical battery cost looms over ‘renewables,’” Committee For a Constructive Tomorrow, December 15, 2022 https://www.cfact.org/2022/12/15/astronomical-battery-cost-looms-over-renewables/

25 James Temple, “The $2.5 trillion reason we can’t rely on batteries to clean up the grid,” *MIT Technology Review*, July 27, 2018 https://www.technologyreview.com/2018/07/27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/

26 Ibid.

27 Mark P. Mills, "The 'Energy Transition' Delusion: A Reality Reset," Manhattan Institute, August 30, 2022 https://media4.manhattan-institute.org/sites/default/files/the-energy-transition-delusion_a-reality-reset.pdf

28 Ibid.

29 Gere Goble, "Crawford County voters uphold ban on industrial wind farm," *Bucyrus Telegraph-Forum*, November 9, 2022 https://www.bucyrustelegraphforum.com/story/news/politics/elections/2022/11/08/crawford-voters-decide-on-wind-farm-development-in-ohio-election-2022/69497527007/

30 Garret Ellison, "Voters defeat Michigan wind energy project, toss supportive officials," MLive, November 9, 2022 https://www.mlive.com/public-interest/2022/11/voters-defeat-michigan-wind-energy-project-toss-supportive-officials.html?outputType=amp

31 Elisabeth Waldon, 'Our community shouted loud and clear,' *The Daily News*, November 9, 2022 https://www.thedailynews.cc/articles/our-community-shouted-loud-and-clear/

32 Sammy Roth, "California's San Bernardino County slams the brakes on big solar projects," *Los Angeles Times*, February 28, 2019 https://www.latimes.com/business/la-fi-san-bernardino-solar-renewable-energy-20190228-story.html

33 Sarah Favot, "L.A. County supervisors to ban large wind turbines in unincorporated areas," *Los Angeles Daily News*, August 28, 2017 https://www.dailynews.com/2015/07/14/la-county-supervisors-to-ban-large-wind-turbines-in-unincorporated-areas/

34 Vince Bielski, "Across U.S., Green Mega-Projects to Power Cities Aren't Playing Well in Mayberry," RealClearInvestigations, July 16, 2020 https://www.realclearinvestigations.com/articles/2020/07/16/across_us_green_mega-projects_to_power_cities_arent_playing_in_podunk_124456.html

35 Ibid.

36 Ibid.

37 Ibid.

38 Ibid.

39 John Murawski, "Solar's Lofty Ambitions Are Consuming Ever-Larger Expanses of Land Down Below," RealClearInvestigations, December 7, 2022 https://www.realclearinvestigations.com/articles/2022/12/07/solars_lofty_ambitions_are_consuming_ever-vaster_expanses_of_land_down_below_868493.html

40 Ibid.

41 Vince Bielski, "Across U.S., Green Mega-Projects to Power Cities Aren't Playing Well in Mayberry," RealClearInvestigations, July 16, 2020 https://www.realclearinvestigations.com/articles/2020/07/16/across_us_green_mega-projects_to_power_cities_arent_playing_in_podunk_124456.html

42 Ute Daewal, Naveed Akhtar, Nils Christiansen, Corinna Schrum, "Offshore wind farms are projected to impact primary production and bottom water deoxygenation in the North Sea," *Communications Earth & Environment*, November 2022 https://www.researchgate.net/publication/365756898_Offshore_wind_farms_are_projected_to_impact_primary_production_and_bottom_water_deoxygenation_in_the_North_Sea

43 Ibid.

44 James Temple, “California’s coming offshore wind boom faces big engineering hurdles,” *MIT Technology Review*, December 5, 2022, https://www.technologyreview.com/2022/12/05/1064243/californias-coming-wind-boom-faces-big-engineering-hurdles/

45 Maria Virginia Olana, “Chart: California’s big bet on offshore wind,” Canary Media, September 16, 2022, https://www.canarymedia.com/articles/wind/chart-californias-big-bet-on-offshore-wind

46 “Levelized Costs Of New Generation Resources and the *Annual Energy Outlook 2022*,” U.S. Energy Information Administration, March 2022, https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

47 “End-of-Life Solar Panels: Regulations and Management” United States Environmental Protection Agency, https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management (Accessed April 4, 2023).

48 Jesper Hvass Schmidt, Mads Klokker, Shilu Tong, editor, “Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review,” National Center for Biotechnology Information, National Library of Medicine, December 4, 2017 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4256253/

49 Kim Willsher, “French couple who said windfarm affected health win legal fight,” *The Guardian*, November 8, 2021 https://www.theguardian.com/world/2021/nov/08/french-couple-wins-legal-fight-wind-turbine-syndrome-windfarm-health

50 Rob Wile, “Tesla car battery ‘spontaneously’ catches fire on California freeway, requiring 6,000 gallons of water to put it out,” NBC News, January 30, 2023 https://www.nbcnews.com/business/business-news/tesla-car-battery-fire-needed-6000-gallons-water-to-extinguish-rcna68153

51 Pool Volume Calculator, GIGA Calcultor https://www.gigacalculator.com/calculators/pool-volume-calculator.php

52 Greg Norman, “Firefighters warn a Tesla fire is ‘one of our worst nightmares,” Fox Business, February 3, 2023 https://www.foxbusiness.com/economy/firefighters-tesla-electric-vehicle-fires-worst-nightmares

53 Sebastian Bell, “Fire Fighters Use 12,000 Gallons Of Water To Extinguish Burning Tesla Model S,” *Carscoops*, November 19, 2022 https://www.carscoops.com/2022/11/fire-fighters-use-12000-gallons-of-water-to-extinguish-burning-tesla-model-s/

54 Ibid.

55 Paul Ciampoli, “Recent California Energy Storage Battery Fire Draws Renewed Attention to Storage Safety Issues,” *Public Power*, October 17, 2022 https://www.publicpower.org/periodical/article/recent-california-energy-storage-battery-fire-draws-renewed-attention-storage-safety-issues

56 Editorial, “Battery fire at Moss Landing a stark reminder of new technology risks,” *Santa Cruz Sentinel*, September 23, 2022 https://webcache.googleusercontent.com/search?q=cache:0Iu8kA1RYd8J:https://www.santacruzsentinel.com/2022/09/23/editorial-battery-fire-at-moss-landing-a-stark-reminder-of-new-technology-risks&cd=8&hl=en&ct=clnk&gl=us

57 Paul Ciampoli, “Recent California Energy Storage Battery Fire Draws Renewed Attention to Storage Safety Issues,” *Public Power*, October 17, 2022 https://www.publicpower.org/periodical/article/recent-california-energy-storage-battery-fire-draws-renewed-attention-storage-safety-issues

58 Neil Farrell, "Questions Over Battery Plants After Moss Landing Incident," *Estero Bay News*, October 21, 2021 https://esterobaynews.com/news/questions-over-battery-plants-after-moss-landing-incident/https://esterobaynews.com/news/questions-over-battery-plants-after-moss-landing-incident/

59 Editorial, "Battery fire at Moss Landing a stark reminder of new technology risks," *Santa Cruz Sentinel*, September 23, 2022 https://webcache.googleusercontent.com/search?q=cache:0Iu8kA1RYd8J:https://www.santacruzsentinel.com/2022/09/23/editorial-battery-fire-at-moss-landing-a-stark-reminder-of-new-technology-risks&cd=8&hl=en&ct=clnk&gl=us

60 Ibid.

61 River Davis, Sean McLain, "Toyota Chief Says 'Silent Majority' Has Doubts About Pursuing Only EVs," *Wall Street Journal*, December 18, 2022 https://www.wsj.com/articles/toyota-president-says-silent-majority-has-doubts-about-pursuing-only-evs-11671372223

62 Julian Dnistran, "Toyota Calls On Science To Tell EV-Only Extremists Tht They're Wrong," *Inside EVs*, February 1, 2023 https://insideevs.com/news/650150/toyota-says-ev-extremists-are-wrong/

63 Mike Collins, "Electric Vehicles Took Off. Car Makers Weren't Ready," *Wall Street Journal*, September 18, 2022 https://www.wsj.com/articles/electric-vehicles-inventory-supply-chain-batteries-11663504014

64 "Critical Minerals in Electric Vehicle Batteries," Congressional Research Service, August 29, 2022 https://crsreports.congress.gov/product/pdf/R/R47227#:~:text=The%20most%20commonly%20used%20varieties,anode%20in%20lithium%2Dion%20batteries.

65 Michael Wayland, "Stellantis CEO warns of electric vehicle battery shortage, followed by a lack of raw materials," CNBC, May 24, 2022 https://www.cnbc.com/2022/05/24/stellantis-ceo-warns-of-ev-battery-shortage-lack-of-raw-materials.html

66 Kate Magill, "A looming graphite shortage could snarl the EV battery supply chain," *Supply Chain Dive*, July28, 2022 https://www.supplychaindive.com/news/graphite-shortage-ev-electric-vehicles-supply-chain/626870/

67 Bart Ziegler, "Electric Vehicles Require Lots of Scare Parts. Is the Supply Chain Up to it," *Wall Street Journal*, November 12, 2022 https://www.wsj.com/articles/electric-vehicles-scarce-parts-supply-chain-11668206037

68 "Is the electric-vehicle revolution putting a strain on battery raw materials?" Autovista24, August 26, 2022 https://autovista24.autovistagroup.com/news/electric-vehicles-raw-materials/

69 Robert Bryce, "Swedish rare earths won't dent China's monopoly for decades," Substack, January 15, 2023 https://robertbryce.substack.com/p/swedish-rare-earths-wont-dent-chinas?utm_source=post-email-title&publication_id=630873&post_id=96943279&isFreemail=true&utm_medium=email

70 "Demand for raw materials for electric car batteries set to rise further," United Nations Conference on Trade and Development, June 25, 2020 https://unctad.org/news/demand-raw-materials-electric-car-batteries-set-rise-further

71 Zack Budryk, "Sweden discovers largest known rare earth mineral deposit in Europe," *The Hill*, January 13, 2023 https://thehill.com/policy/energy-environment/3812388-sweden-discovers-largest-known-rare-earth-mineral-deposit-in-europe/?utm_source=substack&utm_medium=email

72 Robert Bryce, "Swedish rare earths won't dent China's monopoly for decades," Substack, January 15, 2023 https://robertbryce.substack.com/p/swedish-rare-earths-wont-dent-chinas?utm_source=post-email-title&publication_id=630873&post_id=96943279&isFreemail=true&utm_medium=email

73 "Biden's Green-Energy Mineral Lockup," *Wall Street Journal*, January 29, 2023 https://www.wsj.com/articles/biden-administration-mining-duluth-complex-minnesota-superior-national-forest-deb-haaland-electric-vehicles-11674860178?st=tmmoejdr0oj80sv&reflink=desktopwebshare_permalink

74 Ross Pomeroy, "Stanford engineers warn that electric car charging could crash a grid powered by renewable energy," *Big Think*, September 27, 2022 https://bigthink.com/the-present/electric-cars-ev-charging-crash-power-grid/

75 Ibid.

76 Mark Golden, "Charging cars at home at night is not the way to go, Stanford study finds," Stanford News Service, September 22, 2022 https://news.stanford.edu/press/view/45245

77 Siobhan Powell, Gustavo Vianna Cezar, Liang Min, Ines M. L. Azevedo, Ram Rajagopal, "Charging infrastructure access and operation to reduce the grid impacts of deep electric vehicle adoption," *Nature*, September 22, 2022 https://www.nature.com/articles/s41560-022-01105-7

78 The Town of Concord, Massachusetts, *Minuteman Media* https://www.minuteman.media/2274/EV-Miles-Program

79 Wes Venteicher "California bill would require electric vehicles come equipped to supply power to homes" *Politico Pro*, April 18, 2023 https://subscriber.politicopro.com/article/2023/04/california-bill-would-require-electric-vehicles-come-equipped-to-supply-power-to-homes-00092690?source=email.

80 Ibid.

81 Alex Lockie, "California's power crisis poses a serious question for the future of EVs," *Commerical Carrier Journal*, September 27, 2022 https://www.ccjdigital.com/alternative-power/article/15296542/californias-power-crisis-poses-a-serious-question-for-the-future-of-evs

82 "California is poised to phase out sales of new gas-powered cars," National Public Radio, August 25, 2022, https://www.npr.org/2022/08/25/1119381508/california-ban-gas-cars-2035

83 "California Electricity Supply Expectations for Meeting EV Electricity Demand are Based on a Myriad of Assumptions," Institute for Energy Research, January 24, 2023 https://www.instituteforenergyresearch.org/the-grid/california-electricity-supply-expectations-for-meeting-ev-electricity-demand-are-based-on-a-myriad-of-assumptions/

84 Nora Manthey, "Almost 1/3 of San Francisco charging stations are duds," Electricdrive.com, May 13, 2022 https://www.electrive.com/2022/05/13/almost-1-3-of-san-francisco-charging-stations-are-duds/

85 Ibid.

86 "The Expanding EV Market," Plug In America, February 2022 https://pluginamerica.org/wp-content/uploads/2022/03/2022-PIA-Survey-Report.pdf

87 Ben Fordham, "Electric vehicle owners ask neighbours to ration their power," 2GB Sydney, October 13, 2022 https://www.2gb.com/electric-vehicle-owners-ask-neighbours-to-ration-their-power/

88 Nadia Lopez, "Race to Zero: Can California's Power Grid Handle a 15-fold Increase in Electric Cars," *Calmatters*, January 18, 2023 https://calmatters.org/environment/2023/01/california-electric-cars-grid/

89 Draft 2022-23 Transmission Plan posted, California ISO, April 3, 2023, http://www.caiso.com/about/Pages/Blog/Posts/Draft-2022-2023-Transmission-Plan-posted.aspx

90 Sammy Roth, "California's race against time to build power lines," *Los Angeles Times,* April 6, 2023 https://www.latimes.com/environment/newsletter/2023-04-06/californias-race-against-time-to-build-power-lines-boiling-point

91 Robert Bryce, "Out Of Transmission," Robert Bryce, Substack, February 9, 2023 https://robertbryce.substack.com/p/out-of-transmission

92 Ari Plachta, "To cut fossil fuels, California needs power lines, fast. Building them takes a decade," *Sacramento Bee*, December 15, 2022 https://www.sacbee.com/news/politics-government/capitol-alert/article267989567.html

93 Anshuman Sahoo, Karan Mistry, Thomas Baker, "The Costs of Revving Up the Grid for Electric Vehicles, Boston Consulting Group, December 20, 2019 https://www.bcg.com/publications/2019/costs-revving-up-the-grid-for-electric-vehicles

94 Mark P. Mills, Testimony before the U.S. House Select Committee on the Climate Crisis, February 15, 2022 https://www.manhattan-institute.org/mark-mills-grid-resiliance-testimony-house-committee-on-climate

95 Jonathan A. Lesser, "California's Green Debacle," *City Journal*, January 19, 2023 https://www.city-journal.org/californias-green-debacle

96 James B. Meigs, "Delayed Reaction," *City Journal*, February 6, 2023 https://www.city-journal.org/can-nuclear-power-make-a-comeback

97 "President Trump Signs Bipartisan Nuclear Energy Legislation into Law," U.S. Senate Committee on Environment & Public Works news release, January 14, 2019 https://www.epw.senate.gov/public/index.cfm/2019/1/president-trump-signs-bipartisan-nuclear-energy-legislation-into-law

98 Jeffrey Donovan, "'Nuclear is Making a Strong Comeback,' IEA's Birol Tells IAEA Director General Grossi at IAEA COP27 Event," IAEA Department of Nuclear Energy, November 9, 2022 https://www.iaea.org/newscenter/news/nuclear-is-making-a-strong-comeback-ieas-birol-tells-iaea-director-general-grossi-at-iaea-cop27-event

99 David L. Chandler, "Q&A: Options for the Diablo Canyon nuclear plant," *MIT News*, November 8, 2021 https://news.mit.edu/2021/diablo-canyon-nuclear-plant-1108

100 Ibid.

101 Hannah Ritchie, "What are the safest and cleanest sources of energy?" Our World in Data, February 10, 2020 https://ourworldindata.org/safest-sources-of-energy#:~:text=Wind%3A%20In%20an%20average%20year,50%20years%20would%20someone%20die

102 Ibid.

103 "Economics of nuclear power," World Nuclear Association, August 2022 https://world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx#:~:text=Nuclear%20power%20plants%20are%20expensive,included%20in%20the%20operating%20costs.

104 Ashley Finan, "3 Ways to Make Nuclear Power Plants Faster and More Affordable to Build," Office of Nuclear Energy, U.S. Energy Department, July 8, 2021 https://www.energy.gov/ne/articles/3-ways-make-nuclear-power-plants-faster-and-more-affordable-build

105 Ibid.

106 Ibid.

107 California Assembly Bill 65, introduced December 6, 2022 by Assembly Member Mathis https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240AB65&search_keywords=nuclear+and+ban

108 Kerry Jackson, "Capital Ideas: When June Gloom Lasts All Year," Pacific Research Institute, June 20, 2022 https://www.pacificresearch.org/capital-ideas-when-june-gloom-lasts-all-year/

109 Chris Carr, Navi Dhillon, and Lucas Grunbaum "The CEQA Gauntlet: How the California Environmental Quality Act Caused the State's Construction Crisis and How to Reform It" Pacific Research Institute, February 2022 https://www.pacificresearch.org/wp-content/uploads/2022/06/CEQA_Report_Final.pdf.

110 Ibid.

111 Ibid.

About the Authors

Wayne Winegarden, Ph.D., is a Sr. Fellow in Business & Economics, Pacific Research Institute, as well as the Director of PRI's Center for Medical Economics and Innovation.

Dr. Winegarden's policy research explores the connection between macroeconomic policies and economic outcomes, with a focus on fiscal policy, the health care industry, and the energy sector. As Director of the Center for Medical Economics and Innovation, Dr. Winegarden spearheads research and advances policies that support the continued viability and vitality of the U.S. biomedical and pharmaceutical industries to the benefit of patients and overall economic growth.

Dr. Winegarden's columns have been published in the *Wall Street Journal, Chicago Tribune, Investor's Business Daily, Forbes.com,* and *USA Today.* He was previously economics faculty at Marymount University, has testified before the U.S. Congress, has been interviewed and quoted in such media as CNN and Bloomberg Radio, and is asked to present his research findings at policy conferences and meetings.

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He is the author of *Living in Fear in California,* a book that explores well-meaning changes to California's public safety laws enacted in recent years that have undermined safe communities, and offers reforms that strike a balance between the state's obligation to crime victims and the rights of the accused and convicted.

In 2017, he wrote *Unaffordable: How Government Made California's Housing Shortage a Crisis and How Free Market Ideas Can Restore Affordability and Supply*, an issue brief on California's housing crisis which won bipartisan praise. His 2018 brief on poverty in California, *Good Intentions: How California's Anti-Poverty Programs Aren't Delivering and How the Private Sector*

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Jackson is a leading commentator on California's growing homeless crisis. In 2019, he co-authored (with Dr. Wayne Winegarden) a brief on San Francisco's homeless crisis, which was presented to Mayor London Breed's administration.

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Before coming to PRI, Jackson spent 18 years writing editorials on domestic and foreign policy for *Investor's Business Daily* (IBD) and three years as the assistant director of public affairs for the American Legislative Exchange Council. A graduate of Georgia State University, Kerry has also served as a public affairs consultant for the George Mason University School of Law and worked as a reporter and editor for local newspapers in the metro Atlanta and northern Virginia regions.

About PRI

The Pacific Research Institute (PRI) champions freedom, opportunity, and personal responsibility by advancing free-market policy solutions. It provides practical solutions for the policy issues that impact the daily lives of all Americans, and demonstrates why the free market is more effective than the government at providing the important results we all seek: good schools, quality health care, a clean environment, and a robust economy.

Founded in 1979 and based in San Francisco, PRI is a non-profit, non-partisan organization supported by private contributions. Its activities include publications, public events, media commentary, community leadership, legislative testimony, and academic outreach.

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PRI shows how the entrepreneurial spirit—the engine of economic growth and opportunity—is stifled by onerous taxes, regulations, and lawsuits. It advances policy reforms that promote a robust economy, consumer choice, and innovation.

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The Free Cities Center cultivates innovative ideas to improve our cities and urban life based around freedom and property rights—not government.

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