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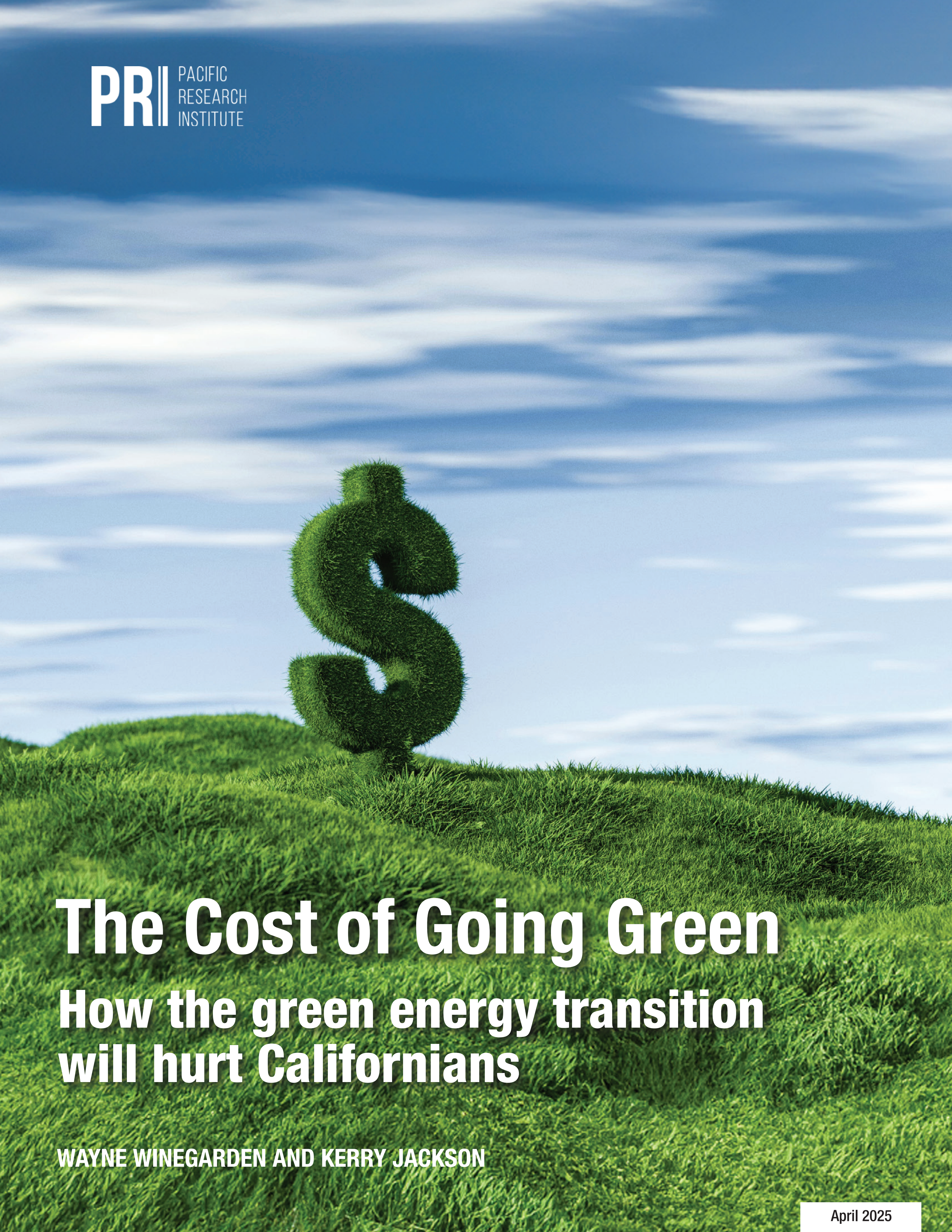

The Cost of Going Green

How the green energy transition will hurt Californians

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April 2025

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Executive Summary

California has two decades to reach its net-zero emissions target. Senate Bill 100, signed by then-Gov. Jerry Brown in 2018, 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."

This paper is the latest in a series of studies by the authors quantifying the costs and real-life impacts on Californians from the state's costly green agenda. Among their previous findings:

- In "Zapped! How California Punishing Energy Agenda Hurts the Working Class" (Winegarden), average annual household electricity expenditures as of 2020 were estimated to be $1,450 – and in some counties as high as $2,000.

  Thanks to green mandates, electricity prices in the state are 56 percent higher than the U.S. average despite state residents using 34 percent less energy.

  If green mandates were reformed or repealed and residential electric rates fell to the U.S. average, California residents could save $517 per year on average.

- In "Sapping California's Energy Future" (Winegarden and Jackson), the impact of the state's 100 percent renewable energy mandates and 100 percent electric vehicle mandates on the state's electric grid was considered.

  The authors found that in 2045, when both mandates would be fully in effect, the state would fall 21.2 percent short daily of the power required to meet the needs of its residents and businesses.

  This calculation does not include the additional electricity required to meet other green mandates, such as prohibitions on gas-powered heaters, air conditioners, water heaters, lawn equipment and stoves, so the deficit is likely much larger. The calculations also ignore the crucial issue of balancing the grid – ensuring the system provides electricity to customers when it is needed.

Despite the likelihood that the Trump Administration will eliminate federal subsidies, California's leaders remain committed to their renewable energy goals. This paper explores the costs that will be borne by Californians in the coming years as the state transitions to the declared all-renewable energy infrastructure.

This transition will be an excessively costly strategy. Residents will be required to pay hundreds of billions of dollars; some explicit, others hidden, in the prices of goods and services that families purchase.

A portion of the costs will be due to constructing and installing the alternative energy infrastructure, the largest and most visible of which will be the purchase of the requisite solar panels, wind turbines, electric vehicles (EVs), and battery infrastructure. Between 2025 and 2050, the present value of the buildout costs is between $209.6 billion and $246.7 billion.

There are also heavy costs for the decommissioning and dismantling of perfectly good but politically disfavored oil development, natural gas plants and nuclear plants that add an additional $17.9 billion in costs. Relatedly, there are the losses created by stranding assets that don't need to be replaced. Consumers will be forced to cover the costs of the new alternative energy investments as well as those for removing existing infrastructure. Consequently, they will be paying the costs of two repetitive energy systems – the new "green" energy generation framework and the prematurely disfavored generation facilities.

Then there are disposal issues with the politically preferred electricity infrastructure that must be addressed. Alternative energy is not magical. In fact, in many ways it works just like the traditional energy infrastructure. Resources are extracted from the earth, used to generate energy, and then must be disposed of once they have reached their end-of-life. Properly disposing of or recycling these resources is imperative, otherwise large adverse environmental impacts will occur. Covering these costs adds another $4.1 billion.

Added together, these costs indicate that a partial accounting of the costs of fulfilling California's politically desired energy infrastructure is between $231.7 billion and $268.7 billion.

PRI's calculations find that California households will be on the hook for between $17,398 and $20,182 in estimated costs to fund the state's energy transition to alternative energy sources between 2025 and 2050. This estimate includes dismantling and decommission costs and alternative energy disposal costs.

There are also many other costs that, while much harder to quantify, are no less real. These include higher future energy costs as the evidence clearly demonstrates that an electricity grid driven by solar and wind generation sources does not lower electricity prices, it raises them. The losses associated with foregone investment opportunities are another cost. When companies are forced to invest their scarce resources in politically preferred alternative energy resources or shutting down otherwise viable energy assets, this means these same resources cannot be used for other purposes. One lost alternative is investments in fireproofing power lines to reduce the probability and/or destructiveness of wildfires.

As if these costs were not sufficient, there are several other obstacles that need to be addressed, including the massive land footprint that wind and solar power require and troubling safety issues that present profound environmental and safety challenges. Industrial-scale batteries that are necessary to plug the intermittency holes characteristic of wind and solar pose a set of dangers all their own, including seemingly spontaneous fires that spew out dangerous chemicals.

Making matters worse, the proponents of California's energy transition steer the conversation away from such basics. Implementing good policy requires that decisions are based on a comprehensive accounting of the policy's costs and benefits. The more important the issue, the more imperative it is that the review is comprehensive and transparent. Ignoring such fundamentals constrains policymakers' ability to effectively address the vitally important issues surrounding global climate change.

Introduction

Alternative energy technologies are not magical; fundamentally, they work just like traditional energy resources. Oil and natural gas provide energy, for instance, when companies extract these resources from the earth, refine them, and then use them to produce the desired energy. The process of producing energy from fossil fuels creates emissions and imposes environmental impacts that must be managed.

A similar process holds for alternative energy.

Take solar panels. Solar panels generate electricity only after workers have mined the requisite minerals and resources from the earth. This includes silicon, rare earth elements, and other metals. These resources must then be transformed into solar panels and, only then, can they be used to produce energy. As with fossil fuel extraction, adverse (and unintended) consequences must be managed as well. These serious issues include environmental damage, harsh impacts on wildlife, and safety concerns for humans. The need to dispose of or recycle the spent solar panels also creates hazards. Managing these risks is critical and comes with a high price tag.

An additional consideration arises with respect to alternative energy. The current goal is not to deploy alternative energy resources to replace generation that has outlived its usefulness or to expand the grid's total generation capacity. The current goal is to retire viable generation resources and replace this capacity with the politically preferred alternative energy sources. Since the sources are replacing a currently viable generation infrastructure, the direct outlays associated with installing the new alternative energy capacity are an additional cost.

Beyond the large direct outlays required to replace perfectly capable energy generation sources, forcing viable energy resources into retirement imposes large decommissioning costs as well as the additional losses that arise due to the government forcing companies to "strand" useful assets. Then there are quality issues. Alternative energy resources, despite tremendous advancements, still face significant limitations that include a more costly and less reliable generation infrastructure. These higher prices and reduced reliability also impose an economic cost.

As California plods forward with its global climate change strategies, these economic and environmental concerns do not garner the attention they deserve – especially in light of the January 2025 Southern California wildfires that will require billions of dollars to replace the huge losses they caused. Ignoring these problems does not make them disappear. Instead of disregarding these vitally important issues, establishing a sustainable global climate change policy requires a transparent accounting of these impacts.

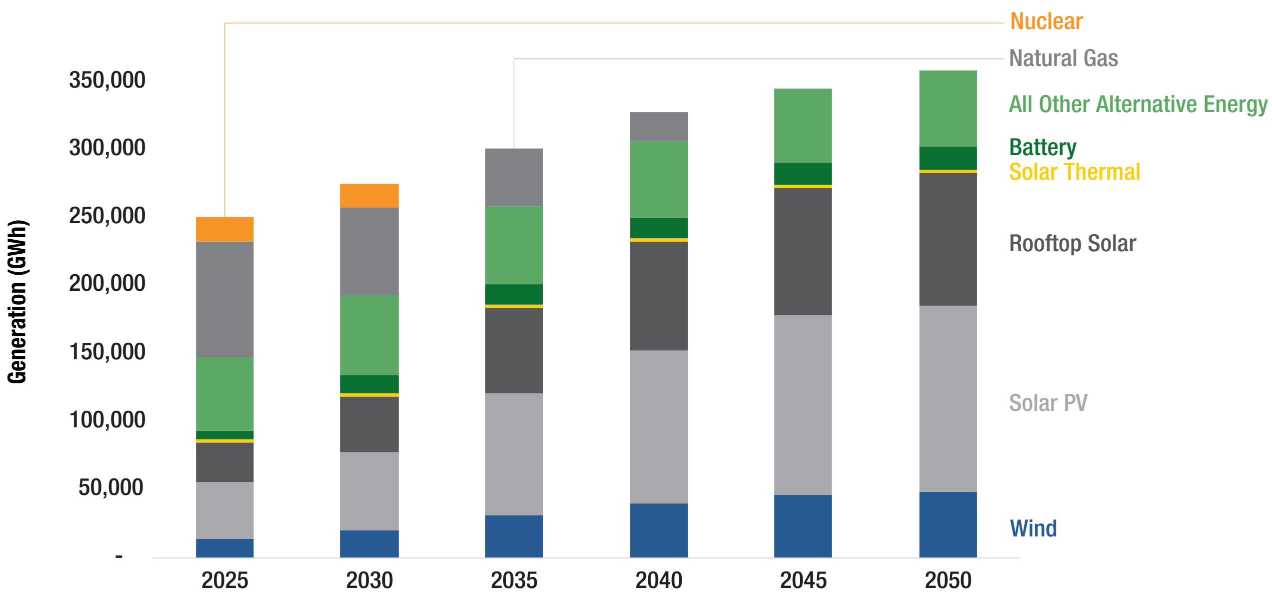
Toward this end, the current analysis provides a partial accounting of the economic, environmental, and safety considerations associated with alternative energy technologies. The alternative technologies considered include solar power, wind turbines, battery storage, and electric vehicles. This accounting demonstrates that California's suite of global climate change policies will cost Californians hundreds of billions of dollars, destabilize the electric grid, create safety concerns for residents, and cause additional environmental harm that must be managed. All the while, the policies will not meaningfully address the problem of global greenhouse emissions. Accounting for these considerations provides more reasons to be skeptical of California's current approach to global climate change.

An Excessively Costly Environmental Strategy

Meeting California's emissions goals requires residents to pay hundreds of billions of dollars. Some of these costs will be explicit, but others will be hidden in the prices of goods and services that families purchase. The costs ultimately imposed on Californians will depend on many unknowns including the amount of generation capacity the state will need, which generation resources will be used to provide the capacity, and what the costs of these resources will be many years into the future. Despite these difficulties, it is possible to get a sense of what these burdens will be.

The California Air Resources Board (CARB) *2022 Scoping Plan for Achieving Carbon Neutrality* projects the new electricity resources needed to meet the desired emissions scenario.[1] Leveraging California's 2023 generation and capacity as maintained by the California Energy Commission,[2] a growth path for total generation and capacity can be estimated. The energy sources generating this electricity reflect the current policy to retire current fossil fuel and nuclear generation facilities and replace this generation with alternative technologies – mostly onshore wind, offshore wind, industrial solar, rooftop solar, and battery infrastructure. Figure 1 presents the sources for the state's required electricity generation between 2025 and 2050.

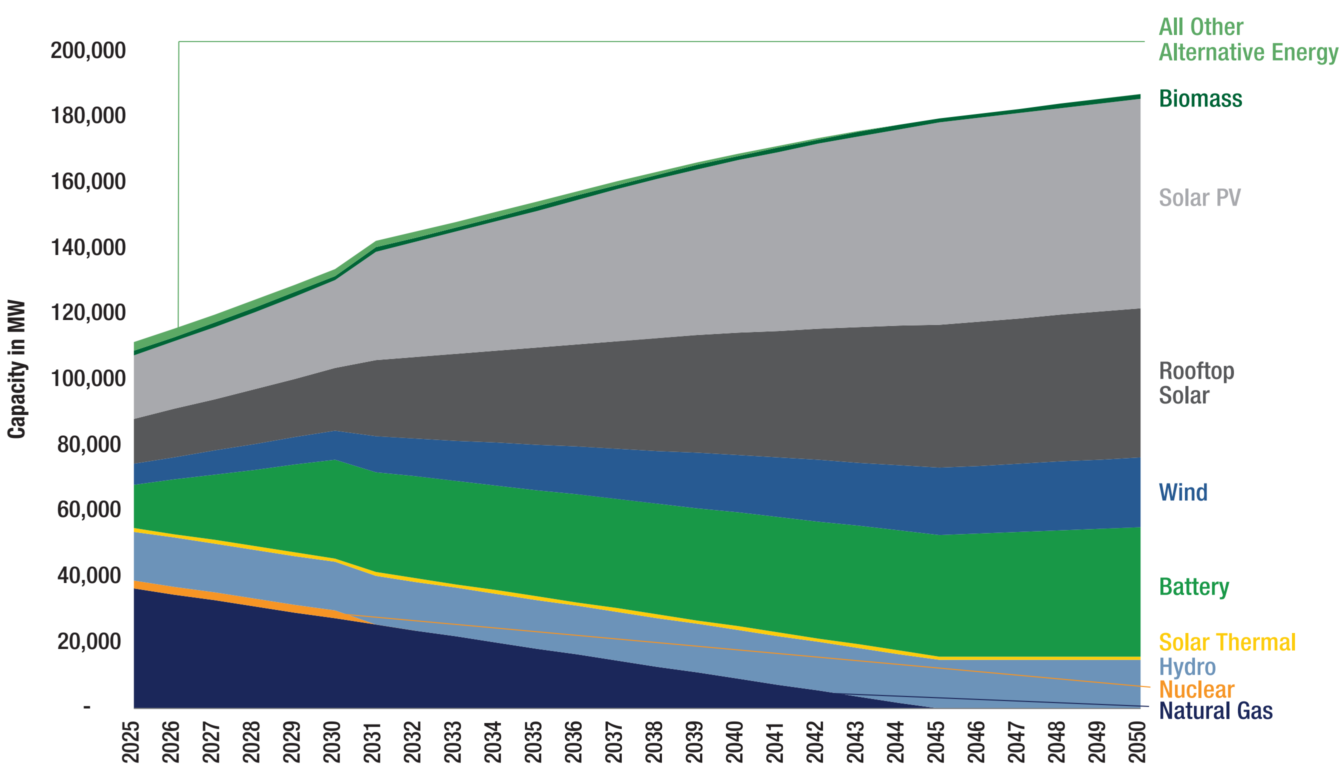
FIGURE 1
EVOLUTION OF CALIFORNIA'S ELECTRICITY GENERATION RESOURCES TRANSITION SCENARIO FOR ALTERNATIVE ENERGY SOURCES 2025 - 2050



Source: Author calculations based on data from CARB and California Energy Commission

Figure 1 illustrates a scenario consistent with the generation requirements as outlined by CARB under the assumption that current nuclear and natural gas power plants will be shut down and that building the required solar, wind, and battery resources is feasible. In total, the scenario assumes that total generation increases, on average, 1.3 percent annually, which is around the average annual increase in generation that occurred in California between 2002 and 2023. The physical infrastructure necessary to meet these generation targets, measured in MW, is estimated based on the current capacity factors for each technology. The results are presented in Figure 2. Figure 2 assumes a transition away from natural gas and nuclear generation facilities over time. In its place utility solar, rooftop solar, wind, and battery storage capacity are assumed to sufficiently grow to replace the disfavored energy resources and to meet expected growth, which includes the needs of electric vehicles but not the increased demand associated with the massive increase in demand due to artificial intelligence, never mind the mandates for electric stoves and heating systems. The boom in artificial intelligence alone is expected to increase data center power demand by 160 percent compared to 2023 by the end of the decade.[3]

FIGURE 2
CALIFORNIA ELECTRICITY CAPACITY
TRANSITION SCENARIO FOR ALTERNATIVE ENERGY SOURCES
2025 - 2050



Source: Author calculations based on data from CARB and California Energy Commission

Importantly, these calculations ignore the many obstacles that could derail the planned transition – including the difficulties constructing offshore wind along California's coast, the technological constraints inhibiting battery storage, and solar and wind's intermittency problem that threaten grid reliability even with the hoped for battery backup.

Ignoring the vitally important issue of viability, there are large costs associated with the energy infrastructure plan outlined in Figures 1 and 2. These include the dollar outlays to build the requisite alternative energy infrastructure, the dollar outlays to decommission the current energy facilities, the higher costs that result from a less efficient generation infrastructure, the stranded asset costs that result from retiring energy generation facilities early, and the opportunity costs that arise due to lost investment opportunities. It is important to note upfront that not all the costs discussed below will be reflected in higher taxes and higher government spending. Other than through higher taxes, Californians will bear these costs through higher utility bills, a less reliable energy infrastructure, and higher payments for goods and services.

The Costs of Construction

Perhaps the largest and most visible costs of the proposed transition are the outlays that state residents must pay to purchase all the requisite solar panels, wind turbines, and battery infrastructure. The 2025 cost estimates in this analysis are based on the current construction costs per kW for solar, wind (onshore and offshore), and battery storage technologies, as summarized in Table 1.

TABLE 1
ASSUMED 2025 CONSTRUCTIONS COSTS FOR ALTERNATIVE ENERGY TECHNOLOGIES $/KW

	Costs/kW
Utility Solar	$1,588
Residential Solar	$2,680
Onshore Wind	$1,451
Offshore Wind	$5,433
Battery Storage	$388/4 hours of storage

With respect to utility solar, according to the U.S. Energy Information Administration (EIA), "average U.S. solar construction costs across all solar panel types increased 1.7% to $1,588 per kilowatt (kW) in 2022."[4] Solar costs for residential systems are $2,680 according to the latest figures from 2023 from the National Renewable Energy Laboratory (NREL).[5] The costs for wind turbines vary depending upon whether they are onshore or offshore. For onshore wind, "the average construction cost for U.S. onshore wind turbines increased 1.6% in 2022 to $1,451/kW"[6] while offshore wind turbines cost $5,443/kW.[7] Costs per kW of battery storage is estimated to be $388 per four hours of storage in 2025 based on a 2023 analysis by NREL.[8]

Construction costs per kW between 2025 and 2050 are projected using two scenarios. The first scenario (low-cost scenario) assumes that productivity improvements continually drive down costs throughout the entire period. The assumed productivity improvement uses NREL's estimated cost improvements for battery technologies for the assumed improvements in the costs for utility solar, residential solar, offshore wind, and onshore wind as well as batteries.[9] The second scenario (high-cost scenario) assumes that the estimated 2025 costs do not change over the entire 2025 through 2050 period. It is important to note that these costs are national averages. California's prevailing wage and other regulatory requirements will likely increase these costs even further.

In addition to these costs, the transition also includes electric vehicle mandates. According to Kelley Blue Book, the average transaction price for electric cars was $55,273 in March 2025 vs. gas-powered vehicles at $48,039 or $7,234 more expensive.[10] Edmunds examined the cost difference between electric vehicles and gas powered cars across different size categories. Across these categories, the average EV costs $15,969 more than the average gas powered car.[11] Operational costs of EVs are less than gas-powered vehicles, however. According to *Consumer Reports,* the average lifetime savings of an EV are between $6,000 and $12,000.[12] Importantly, these savings accrue over the life of the electric vehicle, which is around 12 years on average.[13] Averaging the costs across Kelley Blue Book and Edmunds, EVs are a bit more than $11,600 compared to their gas powered counterparts. Relative to the average estimated EV savings of $9,000, these figures indicate that EVs will cost owners a bit more than $2,600 annually. The total additional costs are estimated by multiplying the net additional EV costs per vehicle by the total number of EVs that are estimated to be purchased over the 25-year period. These purchases are estimated based on the assumption that the historic growth rate in car purchases continues and the current EV mandate percentages will be satisfied.[14]

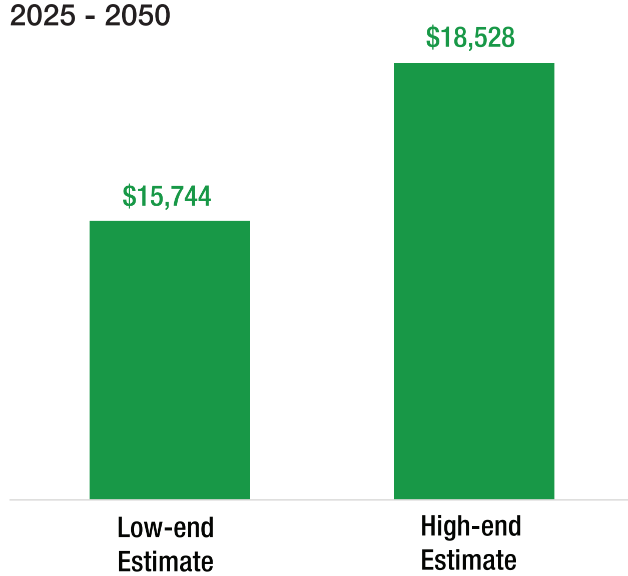
The total construction costs for each year are estimated by multiplying the relevant cost estimate by the estimated increase in generation capacity necessary to reach the energy transition scenario displayed in Figures 1 and 2. The costs incurred in all future years are discounted to account for the time value of money – a dollar received today is more valuable than a dollar received next year. All expenditures starting in 2025 are discounted into their 2024 value based on the same 2.56 percent discount rate. The discounted present value of the additional costs associated with purchasing EVs are discounted using the same methodology. Figure 3 summarizes the results.

As summarized in Figure 3, based on the above assumptions, funding California's energy transition requires between $209.6 billion and $246.7 billion. These estimates are the present value of all future expenditures. Put differently, funding the energy transition requires the state government to place between $209.6 billion and $246.7 billion into an account today. Earning 2.56 percent, this money would generate sufficient resources to fund the required construction costs and additional costs associated with purchasing EVs rather than gas-powered cars between 2025 and 2050. To put these numbers in perspective, paying for the construction and the EV cost premium is essentially imposing between $15,744 and $18,528 in costs on every household in California, see Figure 4.

FIGURE 3
ESTIMATED COSTS TO FUND CALIFORNIA'S ENERGY TRANSITION FOR ALTERNATIVE ENERGY SOURCES 2025 – 2050 (IN BILLIONS)

Source: Author calculations

FIGURE 4
ESTIMATED COSTS PER HOUSEHOLD TO FUND CALIFORNIA'S ENERGY TRANSITION FOR ALTERNATIVE ENERGY SOURCES 2025 - 2050



Decommissioning and Dismantling Costs

The costs of California's energy transition go beyond the required expenditures to buy and install the new preferred energy resources. They also include the costs associated with decommissioning and dismantling the current natural gas and nuclear generation resources. Closing down a generation resource is not as simple as turning off the power and locking the door.

A study by Resources for the Future (RFF) estimates the costs for decommissioning and dismantling fossil fuel generation resources:

> Retirement and decommissioning have different meanings. When a generating unit or an entire plant is retired, it no longer produces electricity. However, the assets of the plant, such as buildings, turbines, boilers, and other equipment, may remain in place. Decommissioning takes place only after a unit or plant retires and refers to the process of environmental remediation, dismantlement, and restoration of the site.[15]

Accounting for these costs is relevant because meeting the politically desired transition goal also means that the state must decommission and dismantle energy resources that, from a technological perspective, are viable.

The RFF study estimates that these costs are, on average, $15,000 per megawatt of natural gas capacity.[16] According to the California Energy Commission, the in-state natural gas generation capacity in 2023 was 39,689 MW.[17] Based on the RFF decommissioning and dismantling cost estimate for natural gas generation, retiring California's current in-state natural gas generation will cost an estimated $595.3 million.

As for the costs for closing nuclear sites, "the decommissioning of a nuclear plant requires the management of three related activities: radiological decommissioning, nonradiological decommissioning and the management of spent nuclear fuel."[18] Closing the San Onofre Nuclear Generating Station cost approximately $4.4 billion.[19] The last remaining nuclear power plant in California is Diablo Canyon. Pacific Gas & Electric (PG&E) estimates that it will cost $4.1 billion to decommission and dismantle this facility,[20] which is around the total costs for San Onofre.

Assuming the Diablo Canyon decommissioning and dismantling estimates are correct, then taken together, closing down the disfavored natural gas and nuclear generation resources and restoring the sites will cost Californians approximately $4.7 billion, which is an additional per household cost of $353.

It is important to note that the decommissioning and dismantling costs also include the oil and gas well operations that, according to current state plans, will be forced out of service. According to a 2023 report by Carbon Tracker, "California's oil sector sits on at least $13.2 billion in onshore decommissioning costs."[21] Adding these $13.2 billion in costs to the $4.7 billion in costs required to close down the operations of the natural gas and nuclear generation facilities, Californians face a $17.9 billion dismantling and decommissioning bill, which equates to $1,344 per Californian household. Adding these expenditures to the costs of creating the desired energy infrastructure, each California household faces a green transition bill that is between $17,088 and $19,872.

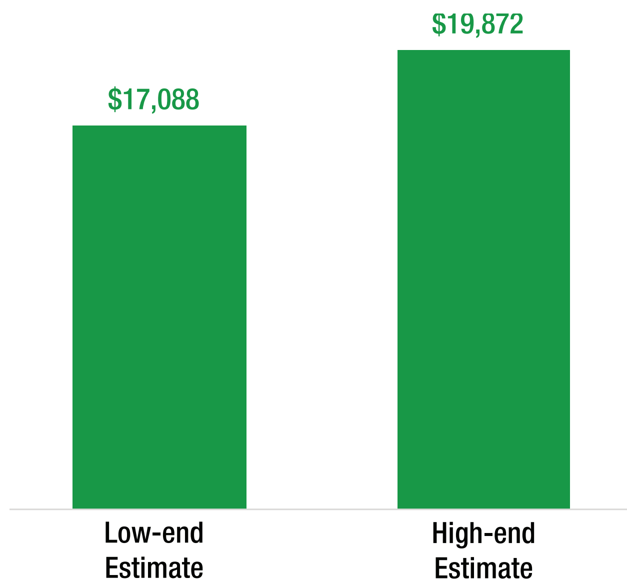
Importantly, these are still only a partial accounting. Many of the other costs that households will face, while no less real, are difficult to quantify. These costs include a less reliable energy system and the costs associated with stranding viable energy assets.

Higher Energy Costs

Proponents of California's energy transition claim that solar and wind energy are lower cost generation resources compared to natural gas and nuclear generation. These claims are based on an energy power statistic known as the levelized cost of electricity (LCOE). For example, an Ernst & Young (EY) study claims "that despite inflationary pressures, solar remains the cheapest source of new-build electricity. The global weighted average levelized cost of electricity (LCOE) for PV is now 29% lower than the cheapest fossil fuel alternative."[22]

Of course, if solar and wind generation resources were truly cheaper and better than the fossil fuel alternatives, then no mandates to transition to these resources would be necessary. Utilities would adopt these technologies on their own to improve their product offerings to customers and profitability to shareholders. Logic dictates that solar and wind resources are not superior to fossil fuel resources because companies must be forced to adopt them. In fact, the data on generation and relative prices demonstrate that adopting a greater share of solar and wind generation does not lower electricity prices, see Figure 6.

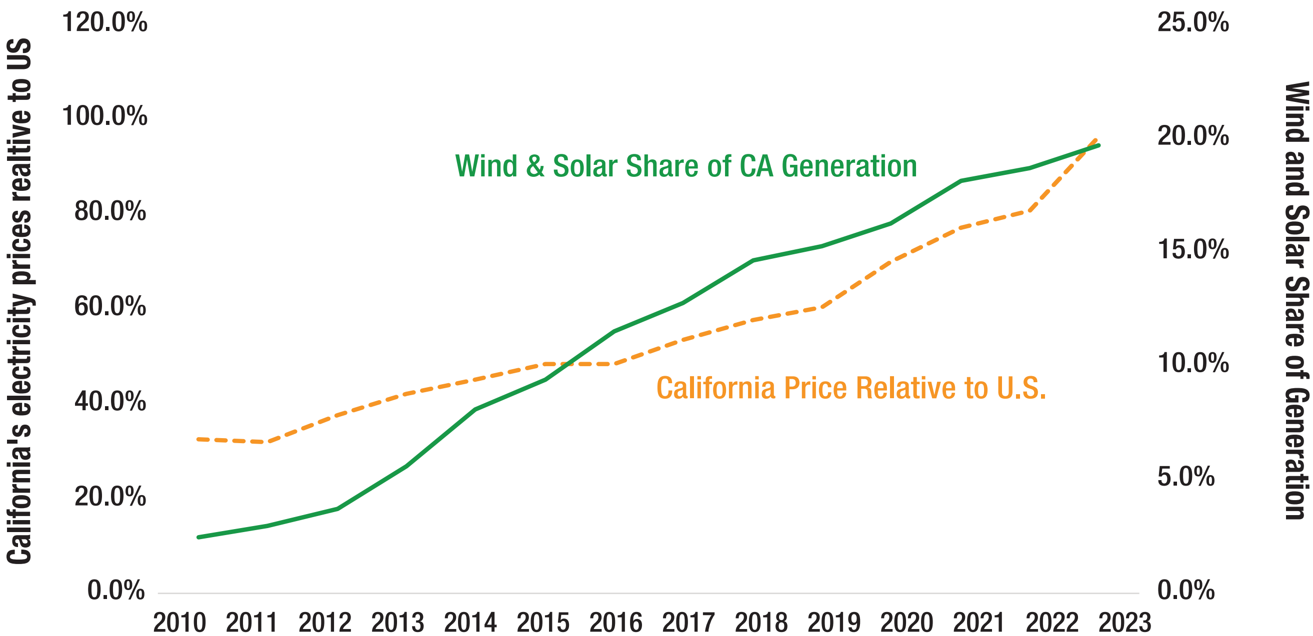
FIGURE 5
ESTIMATED COSTS PER HOUSEHOLD TO FUND CALIFORNIA'S ENERGY TRANSITION FOR ALTERNATIVE ENERGY SOURCES INCLUDING DISMANTLING AND DECOMMISSIONING COSTS 2025 - 2050



Source: Author calculations

FIGURE 6

WIND AND SOLAR'S SHARE OF TOTAL ELECTRICITY GENERATION IN CALIFORNIA COMPARED TO CALIFORNIA'S ELECTRICITY PRICES RELATIVE TO U.S. AVERAGE 2010 – 2023



Source: Author calculations based on California Energy Commission and Energy Information Administration data

Figure 6 compares the share of total electricity generation produced by solar and wind to California's average price relative to the U.S. average price. The data demonstrate that as California has consistently increased its share of electricity generation from these alternative resources, the state's electricity prices have become consistently more expensive relative to the rest of the country. This would not be the case if solar and wind power were less expensive resources.

The California data clearly contradict the assertion by EY regarding the cost of solar power. The answer is that LCOE, while a valuable metric for comparing traditional energy resources, is not an accurate metric for comparing these resources to solar and wind generation. As oilprice.com noted,

> Solar power has been touted as the cheapest available source of energy for several years now. Solar power proponents have been talking about the consistent decline in the cost of raw materials and panel production. They have also talked about LCOE.
>
> The levelized cost of energy is a metric that fans of wind and solar like to cite often. It is calculated using a simple formula where you divide the sum of cumulative costs for an energy project over its lifetime by the amount of total energy the project will generate over its lifetime.
>
> With this formula, wind and solar do look cheaper than gas-fired power plants or nuclear, which require a lot more in upfront investments. But what the LCOE formula does not account for is the fact that wind and solar do not generate electricity around the clock. That's one major cost that is getting overlooked.
>
> Another substantial cost related to renewables that gets overlooked on a regular basis is the need for storage capacity to offset the intermittency problem.[23]

Due to wind and solar power's intermittency problem, which requires additional backup generation and/or storage capacity, these alternative energy resources remain more expensive than traditional generation facilities.

For Californians, this means that they are paying significantly more expensive electricity bills because of the energy transition policies. To get a sense of these costs, the average price per kWh of electricity in 2023 was 24.87 cents in California but 12.68 cents for the U.S. If California's average price premium relative to the U.S. between 2001 and 2009 (46.8 percent) were still applicable rather than California's actual 96.1 percent price premium, then Californians would have spent 18.61 cents per kwh rather than 24.87 cents. Given that the state's total consumption of electricity in 2023 was 281,140 GWh, this translates into an additional $17.6 billion in extra costs that Californians are paying. Unlike the construction and decommissioning costs, these burdens are recurring each and every year.

The Problem of Stranded Assets

Related to the costs incurred decommissioning and dismantling power plants are the costs associated with the forced retirement of viable assets with a longer expected service lifetime. Companies recover the costs incurred when making long-term investments over an assumed number of years. Cutting the years of operation short shortens the opportunity to recover these costs. Due to this shortened opportunity, investments that were otherwise profitable now impose costs that must be realized.

> **"Complying with regulatory requirements to build the politically demanded infrastructure must come at the expense of other alternatives.**

One way these costs can be realized is through lower profits for the power plants, utilities, and investors. Covering these costs will, by definition, either harm company shareholders through lower profits or employees through lower wages and salaries. With reduced profitability, the resources available to invest in new infrastructure or promote other priorities are also lower. The result will be a weaker California economy.

Another option is that customers will bear the brunt of the costs through higher utility bills. Since the investment expenditures were authorized by the regulator in most instances, it is likely that these costs will likely be passed on to consumers. Covering these stranded costs in addition to the covering the costs of the new alternative energy investments essentially means that consumers will be paying the costs of two repetitive energy infrastructures – the new alternative energy generation resources and the prematurely retired disfavored generation resources. These higher than necessary utility costs will also dim California's economic vibrancy.

The existence of these costs is widely accepted. For example, the Environmental Defense Fund noted that the consequences from the stranded assets problem include:

> potential reductions in overall utility investment, rate increases for remaining gas customers, which could unduly burden lower-income and other vulnerable communities and threaten equitable access to energy and the notion of equitable distribution of responsibility and burden amongst a variety of potentially competing stakeholders including current vs. future ratepayers, utility shareholders vs. ratepayers, high income vs. low income customers, and gas vs. electric utility ratepayers.[24]

Unlike the decommissioning and dismantling costs, precisely quantifying the costs associated with stranding viable assets is difficult to estimate a priori because the precise costs will depend on how the problem is managed, future interest rates, and many other unknowns. Overall, these costs are expected to reach billions of dollars and represent a less visible, but no less real burden, on California households.

The Costs from Lost Opportunities

Forcing companies to invest their scarce resources into constructing the politically preferred alternative energy technologies or shutting down otherwise viable energy assets also means these same resources cannot be used for other purposes. For instance, Gov. Gavin Newsom's FY2025-26 January budget proposal allocates "$228.2 million for port upgrades, including construction and improvements of publicly owned port facilities for manufacturing, assembly, staging, and integration of components and vessels, to support the development of offshore wind generation and other activities."[25] This is more money than the governor proposes spending on improving forest health by significantly reducing fuels and improving the resiliency of state lands against destructive fires.[26] Spending $228.2 million on port upgrades means, by definition, that these resources are not available for improving the state's fire resiliency.

What is true for the state government also applies to private energy and utility companies. Complying with regulatory requirements to build the politically demanded infrastructure must come at the expense of other alternatives. These lost investment alternatives could have been more efficient investments that would have created more jobs, reduced energy costs for customers, or delivered a more stable energy infrastructure. The lost alternatives could also have been investments in fireproofing power lines to reduce the probability and/or destructiveness of wildfires.

Since these scenarios are counterfactuals, it is impossible to precisely define which opportunities were lost – either from the government or private-sector perspective. What is known for certain is that these opportunities have been lost and as exemplified by the devastating January 2025 Southern California wildfires, the costs created by lost opportunities may be the largest of all.

From Environmental Hero to Villain

Beyond the financial costs outlined in the previous section, the alternative energy infrastructure outlined in Figure 1 also imposes environmental and safety costs that should not be ignored. Accounting for these costs is important as today's environmental champions often become tomorrow's environmental villains and the pathway from hero to villain can be short and (sometimes) unwarranted.

Take the lawsuit California Attorney General Rob Bonta filed against ExxonMobil in 2024. He claims that the company deceived "Californians for half a century through misleading public statements and slick marketing promising that recycling would address the ever-increasing amount of plastic waste ExxonMobil produces."[27] Even while California's AG vilifies ExxonMobil's efforts, recycling remains a core part of California's and the federal government's strategy for addressing plastic waste.

CalRecycle, a branch of the California Environmental Protection Agency, openly advocates for plastic, stating that "California is addressing plastic waste by building a circular economy" by focusing on cutting, among other priorities, "the amount of plastic waste made," investing and expanding "domestic recycling" and increasing "market demand for recycled plastic by using more recycled content." [28] The U.S. Environmental Protection Agency (EPA) concurs with CalRecycle, noting, "in 2020, Congress passed the Save Our Seas 2.0 Act, which focuses on preventing, reducing and recycling marine litter (such as plastics)."[29]

In other words, Bonta is suing ExxonMobil for advocating for the same recycling programs that California and the U.S. EPA support. Beyond the clear hypocrisy of the AG's efforts, it demonstrates that politicians crowing about the environmental benefits of today's favored technologies does not mean that tomorrow's politicians will not malign these same companies should they fall out of favor in the future – regardless of the merits of the environmental claims.

There are important lessons from this experience for today's alternative energy manufacturers and utilities. Like plastic recycling, alternative energy technologies are widely viewed as part of the solution to reducing total greenhouse gas emissions. Yet, all these technologies create environmental and safety externalities that should not be ignored.

The Sun May Be Free, But Solar Power Is Not

Solar power is considered a "green" source of energy, representing, according to the Environmental Protection Agency, "those renewable energy resources and technologies that provide the greatest environmental benefit."[30] But there's a side to solar power that isn't so green. In fact, it can be downright dirty.

Shining Light On Dark Solar

Solar panels are made from hazardous materials, which do not necessarily make them unique, but their makeup has the potential to create problems when end-of-life disposal is necessary.

These panels use photovoltaic cells to convert sunlight to electricity. They are comprised of benign, everyday materials but also use cadmium, considered a toxic carcinogen. Other raw materials can be "silicon or gallium arsenide, both of which are toxic to the environment if they're not disposed of properly."[31] The Environmental Protection Agency says the metals found in solar panels "are harmful to human health and the environment at high levels." In instances when "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.[32]

The expected lifespan of the average solar panel is 25 to 30 years. By 2050, it is expected that tens of millions of tons of solar panel waste will have accumulated.[33] Disposing of these panels will be costly and fraught with environmental risks. An analysis by the Empire Center for Public Policy states that because solar panels "contain toxic metals, they should be sent to hazardous waste landfills, where disposal costs are around $5 per panel. However, many are sent to municipal solid waste landfills, where disposal costs may be as little as $1 to $2 per panel."[34] It costs $20 to $30 per panel to recycle, while the value of materials is just $3 to $12, "leaving a net cost $8 to $27 — up to 13 times the cost of landfilling. Multiplied by 5 million panels, and that's as much as $135 million per year for disposal."[35]

A *Harvard Business Review* article also notes that:

> The direct cost of recycling is only part of the end-of-life burden, however. Panels are delicate, bulky pieces of equipment usually installed on rooftops in the residential context. Specialized labor is required to detach and remove them, lest they shatter to smithereens before they make it onto the truck. In addition, some governments may classify solar panels as hazardous waste, due to the small amounts of heavy metals (cadmium, lead, etc.) they contain. This classification carries with it a string of expensive restrictions – hazardous waste can only be transported at designated times and via select routes, etc.
>
> The totality of these unforeseen costs could crush industry competitiveness.[36]

The implication for these costs, according to the authors, could quadruple solar's LCOE, making solar power prices uncompetitive even based on the inappropriate LCOE metric.

Solar's Footprint

The American Farmland Trust projects that more than 2.5 million acres of land will be "converted to utility-scale solar photovoltaics energy generation facilities across the contiguous U.S." from 2020 to 2040.[37] That works out to a little more than 3,900 square miles, more area than Delaware and Rhode Island combined. The breakdown by land type is shown in Table 2. Converting these diverse types of land from valuable resources such as fertile farmland and turning them into solar panel fields imposes a large opportunity cost on Californians – the economic output, jobs, income, and tax revenues that could have been gained from these alternative uses is lost.

TABLE 2
PROJECTED LAND DEVOTED TOWARD UTILITY-SCALE SOLAR PRODUCTION BY 2040

Cropland	1,017,500 acres
Pastureland	358,500 acres
Rangeland	652,000 acres
Woodland	70,500 acres
Forestland	340,900 acres
Other	95,300 acres
Total	**2,534,800 acres**

Source: Beck, Hunter, Murphy, and Sorenson (2022)

Nearly half – 49 percent – "of the solar conversion on agricultural land is projected to occur on Nationally Significant land, the nation's best land for long-term production," says the trust. Developers choose "high-quality farmland" to site solar arrays because "it is more likely to be flat, dry, cleared, and close to existing infrastructure."[38]

Forests are chosen because they act as buffers to farmland and other open spaces. But this can produce "cascading effects that remove agricultural runoff and flooding controls, reduce biodiversity and pollinator habitat, and increase pest abundances — all of which can detrimentally impact farmland."[39]

Trees are being cut through mass deforestation to make space for solar panels even though they absorb carbon dioxide, the gas that the environmentalists want to reduce by transitioning to renewable sources. The amount of CO_2 in Massachusetts' tree cover, for instance, is the equivalent of five years of statewide CO_2-producing fossil fuel emissions.

In addition to flood-control difficulties, tree loss leaves humans vulnerable to windstorms, endangers wildlife habitats, and negatively impacts pollination.[40] As researcher Jonathan Thompson told the *Harvard Gazette*,

> We need to think not only about how many acres we're using for solar development, but also which acres are being developed. Our core forests are incredibly valuable for wildlife habitat, biodiversity, and carbon storage, and we must do everything we can to protect them from further fragmentation.[41]

Solar farms are harmful to future forests even when there's no clear cutting involved because the arrays block new forest growth. Natural forests cannot develop where a solar farm or "solar forest" already exists.

The open desert might appear to be the ideal location for a solar farm, but all things are not as they seem. When a solar farm is built, "the desert crust that binds soil — and absorbs carbon dioxide like a sponge — is disturbed," says journalist Vince Bielski. This makes solar far less appealing when the goal is to cut atmospheric carbon dioxide concentrations.[42]

Eventually, available space will run short, not due to physical limitations but because "the easy land is gone," says Kern County, California, Director of Planning Lorelei Oviatt. "The tolerance of local governments and local communities for hosting is gone."[43] While there are alternative sites, such as rooftops and "disturbed land" – "where the natural conditions and processes have been impacted by development (e.g. facilities, roads, mines, dams, abandoned campgrounds) and/or by agricultural practices (e.g. farming, grazing, timber harvest, abandoned irrigation ditches)"[44] – "those options are often expensive and impractical," says John Murawski of RealClearInvestigations.[45]

Land is not the only resource that is gobbled up by solar power sites. Enormous volumes of water are consumed in the manufacturing process. Semiconductor factories (solar arrays are packed with semiconductors), for instance, go through hundreds of millions of gallons of water every year.[46] Furthermore, the wastewater that is produced by solar panel production is tainted by "a variety of contaminants, such as chemicals, metals, suspended solids, and organic compounds."[47]

Water is also needed to keep desert-based solar systems cool, as heat causes an efficiency loss, and to keep the panels clean, as well.[48] To be fair, solar energy typically needs less water to operate than fossil fuel and nuclear power, but the amount is not zero, as some have claimed. The *Las Vegas Sun* has reported that "a large photovoltaic array can still easily use more water in a year than an entire residential block."[49]

Concentrating solar thermal plants are even thirstier. Solar thermal plants don't use photovoltaic panels but mirror fields to reflect sunlight onto "power tower receivers near the center of each heliostat array," according to the California Energy Commission's description. The heat produces steam, which turns a turbine that produces electricity.[50] The Ivanpah solar thermal facility in San Bernardino County, California, just south of Las Vegas, uses a dry cooling system. But this is not uniform across the industry. Concentrated solar power can use as much as 3,500 liters of water for each megawatt hour of electricity generated, significantly more than the roughly 1,000 liters per megawatt hour consumed by modern natural gas-fired power plants.[51]

The San Bernardino plant, just 11 years old, is an environmental menace, according to activists, and might be in line to be shut down. On roughly five square miles, and at one time the world's largest facility of its type, it was considered to be on the cutting edge of renewable energy. But it's been reported that it "has been struggling to compete with cheaper solar technologies" and has "been blamed for incinerating thousands of birds." Critics also say it's been a threat to tortoises and rare plants. Julia Dowell of the Sierra Club calls the Ivanpah site a "financial boondoggle and environmental disaster."[52]

Rooftop solar is not without issues. With 14.2 gigawatts, there is far more rooftop (small-scale) solar panel capacity in California than in any other state. In fact, the combined capacity of the next seven states in the rankings – New York, New Jersey, Texas, Arizona, Massachusetts, Florida, and Maryland – equals California's total.[53] And while the state has a scheme to proliferate solar panels, it "had no comprehensive plan to dispose of them."[54] "Many are already winding up in landfills, where in some cases, they could potentially contaminate groundwater with toxic heavy metals such as lead, selenium and cadmium," the *Los Angeles Times* reported in 2022.[55] With only one in 10 panels recycled, "The looming challenge over how to handle truckloads of waste, some of it contaminated, illustrates how cutting-edge environmental policy can create unforeseen problems down the road," said the *Times*.

Safety and Operational Deficiencies Plague Wind Turbines

On the evening of July 13, 2024, a 300-foot span from the blade of an offshore wind turbine the size of the Eiffel Tower broke and fell into the water. Because of the turbine's location, 14 miles from Martha's Vineyard, Massachusetts, the debris, as much as six to seven truckloads, eventually washed up on the shores of Nantucket and Cape Cod, with "thousands of pieces of fiberglass shards and green and white foam" landing on the former's coastline.[56] At least six Nantucket beaches had to be "closed to swimming due to debris that washed ashore," according to the local media.[57]

The word from the Nantucket harbormaster was "You can walk on the beaches, however we strongly recommend you wear footwear due to sharp, fiberglass shards and debris on the beaches."[58]

By early August, the cause had not been determined, though Scott Strazik, CEO of GE Vernova, manufacturer and installation contractor for the Vineyard Wind project, said that a preliminary examination indicated "that the affected blade experienced a manufacturing deviation."[59] Later in the month, "Scores of fishermen took to the seas" to protest offshore wind developments after that "blade scattered toxic debris off the coast of Massachusetts," the *Daily Caller* reported.[60] "The flotilla protested the effects of offshore wind on fish stocks and ocean navigation, with roughly 20 ships making a sixty-mile round trip from New Bedford, Massachusetts, to the site of the broken turbine."[61]

Environmental harm from wind turbines and turbine blades is not unique to offshore sites. Turbine fires due to lightning strikes can also occur. For instance, on August 15, 2024, at 5 a.m., an Iowa farming family took a call from a neighbor who said, "Your wind turbine's on fire again."[62] The family

> agreed in 2012 to an easement with Acciona Wind Power to install two turbines on the family farm in Cedar County. But within the last 18 months, both turbines have been struck by lightning — and now, one of them twice.
>
> The strikes left fiberglass, dust and other debris strewn over at least 240 acres, almost a third of the farm's land. And with the fall harvest underway, the family's frustration with having the damaged turbines removed and the debris cleaned up is threatening their bottom line.
>
> "We're trying to figure out what's going to happen to that corn," said [Sally] Freeman, 31, owner of the farm. "We don't know if it's going to have to end up in a landfill, or if there is some type of place to go salvage it, or a different market to put it into. I hate to have to haul that much corn to the landfill, especially a year like this year where we're looking at really good yields."[63]

Photographs published by the *Cedar Rapids Gazette* show a broken, idled turbine and scarred earth where the sail (blade) landed. The cleanup process was still incomplete two months after the most recent incident.

The Challenges of Disposing Retired Turbine Blades

Concerns about the "environmental conundrum" of no-longer-useful wind turbine parts are not new. "As the first wave of windmills reach the end of their lives, tens of thousands of blades are being stacked and buried in landfill sites where they will take centuries to decompose," Reuters reported in September 2021.[64] "Wind Europe, a Brussels-based trade association which promotes the use of wind power in Europe, expects 52,000 blades a year to need disposal by 2030, up from about 1,000 today."[65]

In the U.S., more than 2 million tons of wind turbine blades are expected to be retired by 2050.[66] The blades are also growing larger. The average length is about 50 meters, a little more than 164 feet, a bit longer than the width of a football field.[67] But "with recent trends to use longer blades on bigger turbines and taller towers to increase electricity production, a few of the largest blades produced today reach 60-80 meters in length," says the Union of Concerned Scientists.[68] Larger blades, of course, add to the volume of the solid waste stream.

In addition to their sheer size, blades are also sturdy, made to withstand the elements and the mechanical movement. They are primarily manufactured of composite materials that combine high tensile-strength fibers with polymer resins, which form glass- or carbon-fiber-reinforced polymers, meaning that "their strength and durability present challenges for disposal."[69] While not as toxic as solar panels, there are nearly 72,000 utility-scale wind turbines across the country mostly the three-sail variety, and they too present environmental impacts if not handled properly at the end of their useful lives, endangering both land and water.[70]

Optimists expect that recycling will solve the disposal problem, but recycling remains more expensive at current rates. Overall, the Department of Energy estimates, based on "limited review of eight decommissioning estimates," that "per-turbine decommissioning costs (total decommissioning costs divided by number of turbines) of $114,000–$195,000. When salvage estimates were included, decommissioning costs were reduced to a net range of $67,000–$150,000 per turbine."[71] With roughly 5,456 turbines in California, the cost to dispose of just the existing wind turbine infrastructure will cost between $365.6 million and $818.4 million. As the state plans to grow the infrastructure, the costs will only increase from there.

The Battery Complication

The intermittent nature of solar and wind requires energy additional infrastructure that will provide energy when they don't. A preferred option for environmentalists is that a portion of the electricity these sources generate is to be stored in grid-scale battery systems, which themselves pose environmental complications and risks. Like renewable energy sources, battery farms need space. The world's largest solar-plus-storage facility is the Edwards & Sanborn project in Kern County, California.[72] It requires 4,600-acres to produce a little more than 800 megawatts of electricity – (there are 1.9 million solar panels on-site) – and to store nearly 3.3 gigawatt-hours of power.[73]

The second largest is also in California.[74] Vistra's battery facility at Moss Landing in Monterey County takes up 22 acres and can store 1.6 gigawatt-hours of electricity.[75] Another 53 acres is occupied by a natural gas plant that produces 1,060 megawatts of energy, more than is generated by the sprawling, far larger solar array at the Edwards & Sanborn site in Kern County.[76]

Vistra has a spotty record. In September 2021, when the Vistra facility was the world's largest, it experienced an emergency shutdown when battery packs overheated.[77] They didn't catch fire, but they did fill the building with smoke. The following September, battery packs overheated again, and this time caught fire. Officials had to cordon off the area for about three kilometers in all directions. Local residents were advised to stay indoors, to keep their windows closed, and to bring their pets inside.

The Moss Landing facility caught fire again in January 2025, "raging out of control" and "sending up huge flames and clouds of hazardous black smoke," and forcing the evacuation of roughly 1,200 nearby residents.[78]

As of 2023, there were a total of only 6.6 gigawatts of battery storage in the state.[79] For California to meet its projected need of 52 gigawatts of energy storage capacity by 2045, many more battery farms of similar size to these sites will need to be built. The buildout will not only disturb the environment due to land needs, but it will also increase the fire risk in California, which, due to environmental regulation and green initiatives, has a wildfire problem. Urban and suburban areas can be at risk, as well.

"The spread of BESS [battery energy storage systems] over the past 10 years has been accompanied by a rise in the frequency of spontaneous fires. Up to July 2024 there have been 89 BESS fires recorded worldwide," according to a report from Net Zero Watch.[80]

When a single lithium battery cell catches fire, it can set off an event – thermal runaway – which is a non-nuclear chain reaction. After the first cell bursts into flames, it "will heat up adjacent cells, which will also burst into flames." The infernos produce clouds of noxious gases, toxic smoke, and a tremendous explosive potential. A fully charged 1-megawatt-hour BESS stores the "electrochemical energy of many hundreds of tons of TNT equivalent," say researchers, "several times the energy released in the August 2020 Beirut explosion," which was probably at least a half-kiloton and maybe as much as 2.7 kilotons.[81]

Electric Vehicles Create Safety and Environmental Risks

Hurricanes Helene and Milton vividly demonstrate the shortcomings of electric vehicles, which we've been told are going to help save us from global warming as they don't directly burn fossil fuel. High water is often fatal to EVs, though, and Helene dumped more than 40 trillion gallons of rain in the Southeast U.S., enough to fill Lake Tahoe.[82] Because water conducts electricity, it can cause EV batteries to short by effectively connecting the positive and negative terminals in the case of submersion. This can cause thermal runaway. During Hurricane Ian in 2022, somewhere between 3,000 and 5,000 EVs were flooded. Six hundred were written off as total losses, including 36 that caught fire.[83]

Business Insider reported shortly after Hurricane Helene ripped its way through Florida, Georgia, Tennessee, Virginia and the Carolinas that "viral videos of EVs catching fire" raised safety concerns in Florida.[84] Meanwhile, the local media in Orlando, Florida, noted that an electric vehicle fire had added to the storm's devastation in the state.[85]

Shut Down by EV Fires

EV fires are a growing risk regardless of hurricanes. Interstate 15 between Los Angeles and Las Vegas can be a slog to drive at any time, but what should be a four-hour trip was made worse when at about 6 a.m. on July 31, 2024, a big rig with a 75,000-pound trailer carrying industrial-grade lithium-ion batteries overturned and caught on fire.[86] The inferno emitted toxic fumes and was a threat to explode. In response, "officials shut down both directions of travel as they worked to extinguish the flames and move the dangerous cargo."[87]

"Travelers ended up stranded for hours on both sides of the freeway, as well as on the 40 Freeway, which became overwhelmed with traffic from people trying to get around the 15 Freeway closure."[88] The crash occurred on a Friday morning. It wasn't until roughly 3 p.m. on that Saturday that southbound lanes of I-15 were reopened. The northbound lanes were "closed until about 4 a.m. Sunday after the stubborn flames were finally extinguished."[89]

An entire electric rig caught fire in August 2024 on Interstate 80 in Placer County, California. The National Transportation Safety Board said a 2024 battery-electric Tesla truck-tractor, was involved in a single-vehicle crash, which resulted in the vehicle's lithium-ion electric battery system igniting and causing a post-crash fire. Emergency responders used "about 50,000 gallons of water to extinguish the flames and cool the vehicle's batteries" and the California Department of Forestry and Fire Protection was called to fly in "an aircraft to apply fire retardant to the immediate area as a precautionary measure."[90]

The California Highway Patrol said the fire burned as hot as 1,000 degrees Fahrenheit.[91] *Road & Track* reported the Tesla was eventually moved "to an open-air location and kept under observation for 24 hours to make sure the batteries didn't catch fire again," because the re-ignition of lithium-ion fires "can be a problem" "as their makeup effectively gives them all three parts of the so-called 'fire triangle' needed for a blaze to occur."[92]

The problem of exploding batteries is not confined to the large electric trucks either. In June 2024, a Brooklyn man was critically injured in a fire that was started by an exploding lithium-ion battery being charged on an e-bike.[93] In all, four people were injured, including the man whose life-threatening injuries required him to be rushed to the hospital.[94] Later that year in December 2024, a fire broke out in Brooklyn while an e-bike was charging creating "extensive damage and thousands of dollars in losses."[95]

The Costs and Risks of Battery Disposal

The fire risks of lithium-ion batteries persist even after the electric vehicle is no longer drivable and is ready for disposal. The "EPA determined that most lithium-ion batteries on the market are likely to be hazardous waste when they are disposed of because they may catch fire or explode if not handled carefully. Most lithium-ion batteries when discarded would likely be considered ignitable and reactive hazardous wastes."[96]

Due to the large amount of hazardous materials, the batteries must be disassembled at disposal. As the American Energy Alliance noted, the EV battery cells

> can release toxins, including heavy metals that can leak into the soil and groundwater. A study from Australia found that 98.3 percent of lithium-ion batteries end up in landfills, which increases the likelihood of landfill fires that can burn for years. One landfill in the Pacific Northwest was reported to have had 124 fires between June 2017 and December 2020 due to lithium-ion batteries. Fires are becoming increasingly more common, with 21 fires reported on the site in 2018, increasing to 47 by 2020.[97]

Consequently, separating out and properly handling the dangerous components that could otherwise leak into the soil and groundwater if the battery is simply left in a landfill is essential. While recycling is a viable solution to this problem, the task is quite difficult. As summarized by MIT's Climate Portal:

> The packs from a Tesla, BMW, and Nissan EV are different sizes, containing differently-shaped battery cells joined together by welds and other connections that must be broken down. This complexity makes the process more expensive and dangerous.
>
> "The significant challenge in battery recycling is the variability in chemistry and form factor, and that we have to be cautious to discharge them when they are recovered," (MIT professor Elsa) Olivetti says. That's especially important because old or broken lithium-ion batteries can catch fire, which adds to the danger of stockpiling them for disposal.[98]

"The fire risks of lithium-ion batteries persist even after the electric vehicle is no longer drivable and is ready for disposal.

Due to these concerns, the end-of-life stage of EV batteries creates additional environmental and safety risks that must be managed. These dangers impose additional costs that further erode the affordability of the EV technology.

The High Costs to Manage “Clean Energy’s” Toxic Side

Whether it is fires, environmental damage, or dangerous debris, the safety and ecological threats from the current alternative energy technologies are not insignificant. They are part of the largely untold story of environmental damage being caused by so-called clean energy. The scale of the environmental risks are not being adequately addressed by California’s policymakers.

To get a sense of the disposal costs, we assume the typical lifespan and estimated disposal/recycling costs for the alternative energy infrastructure, which is presented in Table 3. Applying these costs and lifespans to the physical requirements outlined in Figure 7 provides an estimated disposal cost for the alternative energy infrastructure that the state is mandating. Since these costs are incurred over time, the discounted present value is estimated based on the same 2.6 percent discount rate. Based on these assumptions, California will incur a $4.1 billion disposal bill through 2050 that it must pay to properly dispose of its alternative energy infrastructure. On a per household basis, this equates to an additional $310.

TABLE 3
AVERAGE LIFESPAN ALTERNATIVE TECHNOLOGIES

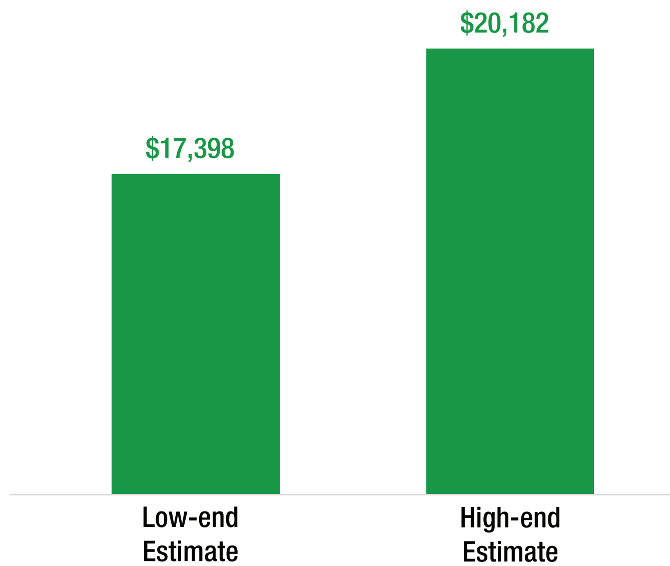
	Lifespan (in years)	Estimated Average Disposal Cost	
Solar	30	$5.00 - $17.50	Net for recycling, per panel
Wind	30	$67,000 - $150,000	Per turbine
EVs	10	$150.00	Per metric ton
Storage Batteries	20	$150.00	Per metric ton

Sources: Various[99]

Incorporating these expenses into the running total illustrates that the quantified costs associated with California's energy transition and its proper disposal are between \$231.7 billion and \$268.7 billion. Putting these costs in perspective, to ensure that the state has the sufficient resources to cover them, it would have to collect between \$17,398 and \$20,182 from every household in California today. And these costs do not account for the costs associated with the lost opportunities, any potential environmental damage from the use or improper disposal of these technologies, and any inefficiency losses created by the less reliable and more expensive energy infrastructure. In other words, it is only a partial accounting. The total bill is even higher.

FIGURE 7

ESTIMATED COSTS PER HOUSEHOLD TO FUND CALIFORNIA'S ENERGY TRANSITION FOR ALTERNATIVE ENERGY SOURCES INCLUDING DISMANTLING AND DECOMMISSIONING COSTS AND ALTERNATIVE ENERGY DISPOSAL COSTS 2025 - 2050



Source: Author Calculation

Conclusion and Recommendations

Sound policy fully considers the costs long before the state begins to reap the consequences. In this report, we provided a partial accounting of the costs associated with developing the politically desired alternative energy infrastructure, dismantling and disabling the current fossil fuel generation sources, and the costs associated with safely disposing of the alternative energy technologies once they have reached the end of their expected useful lifespan. Additional concerns include potential environmental challenges, the lost benefits from alternative investment opportunities, the higher energy costs associated with the politically desired infrastructure, and the impact of alternative energy technologies on grid reliability.

In total, we estimate the present value of these costs between 2025 and 2050 is between $231.7 billion and $268.7 billion, or between $17,398 and $20,182 per California household. These large costs suggest that greater caution regarding California's headlong rush into the energy transition is warranted. Rather than forcing an expensive transition whose expected benefits with respect to global greenhouse gas emissions are anticipated to be insignificant, California's policymakers should rethink their global climate change strategy.

As we recommended in *Sapping California's Energy Future*,[100] California should repeal its 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.

"Rather than forcing an expensive transition whose expected benefits with respect to global greenhouse gas emissions are anticipated to be insignificant, California's policymakers should rethink their global climate change strategy.

For the foreseeable future, nuclear generation remains an essential low-emission, affordable generator of electricity. 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.[101]

The International Energy Agency has declared that "nuclear power is making a comeback — and in a strong fashion."[102] 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."[103] 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."[104]

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 safe (of all energy sources only solar is safer in terms of fatalities and the difference is negligible[105]), reliable (it can generate electricity on demand), and green (its greenhouse gas emissions are lower than all sources of energy[106]). 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.[107]

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."[108]

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."[109]

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."[110]

Small modular nuclear power units also hold promise that should be explored. 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.[111]

As impressive as these new generation reactors are, sustainably addressing global climate change while maintaining energy affordability ultimately requires continued innovation. While the government of California is not well positioned to drive these innovations, policymakers still have an important role to play: Establish 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."[112] CEQA notoriously increases the costs for construction projects from housing to transportation.[113]

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 substantial 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. These incentives should be broad-based to prevent state government from picking winners and losers.

" 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.

A market driven approach that embraces the technologies that work today while empowering the millions of California residents to drive the energy revolution is the surest path to creating an affordable, reliable, and lower-emission energy infrastructure.

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About PRI

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