



Assessing the Costs of Regulations to Reduce CO₂ and Other Greenhouse Gas Emissions

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I. Introduction

In 2009, the U.S. Environmental Protection Agency (EPA) determined that increased concentrations of six greenhouse gases (GHGs) should be classified as pollutants that were endangering “the health and welfare of current and future generations.”¹ Although the EPA’s “Endangerment Finding,” as it is commonly called, initially focused on emissions from motor vehicles, the finding has been used to regulate GHGs from mobile and stationary sources under the Clean Air Act. In an accompanying Technical Support Document, the EPA cited numerous potential future impacts of increasing GHG concentrations.²

The Endangerment Finding has been used to justify various state and federal regulations and policies designed to reduce GHG emissions. For example, EPA’s 2015 Clean Power Plan (CPP), which was later rescinded in 2019, sought to reduce GHG emissions from fossil fuel electric generating plants by directly regulating these emissions. Subsequently, in April 2024, the EPA announced new carbon emissions standards, known as “Clean Power Plan 2.0,”³ for natural gas-fired and coal-fired generating plants. These standards require existing base-load plants (defined by the EPA as those operating at a capacity factor of greater than 40%) to reduce CO₂ emissions per megawatt-hour (MWh) by 90% no later than January 1, 2032, unless the plants cease operations before January 1, 2039. The only physical way to achieve such emissions reductions is by installing carbon capture technologies.

Although the EPA and many states have estimated the *benefits* of those reductions using estimates of projected monetary damages from GHG emissions (the “social cost of carbon”),⁴ the actual *costs* of GHG reductions (e.g., higher energy prices, less reliable energy supplies) and their implications for human health and welfare have not been seriously considered by the regulators.

For example, the Inflation Reduction Act of 2022 greatly expanded the scope of subsidies for renewable energy resources. The costs of these subsidies, including the costs of financing them with additional debt issuances by the U.S. government, have been estimated to be almost \$5 trillion.⁵ Given the country’s current and rising indebtedness, the economic implications of these

¹ Environmental Protection Agency (EPA), “[Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202\(a\) of the Clean Air Act](#),” December 7, 2009.

² Ibid., “[Technical Support Document](#).”

³ EPA, “[Final Rule: NSPS for Greenhouse Gas \(GHG\) Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units \(EGUs\); Emission Guidelines for GHG from Existing EGUs and Repeal of the Affordable Clean Energy Rule](#),” April 25, 2024.

⁴ Jonathan A. Lesser, “[The Social Cost of Carbon: A Flawed Measure for Energy Policy](#),” National Center for Energy Analytics, April 23, 2025.

⁵ Travis Fisher and Joshua Loucks, “[The Budgetary Cost of the Inflation Reduction Act’s Energy Subsidies](#),” Cato Institute, March 11, 2025. See also Jonathan A. Lesser, “[Green Energy and Economic Fabulism](#),” Global Warming Policy Foundation, December 1, 2023.

subsidies include higher energy costs, inflationary pressures, and crowding out private investment. This is why calls to eliminate or scale back those subsidies have increased.⁶

The purpose of this report is to provide a catalog of those costs.

II. Regulation of Stationary Emission Sources

Under the Clean Air Act, the EPA has the authority to regulate emissions from stationary sources. Although most of the regulations focus on electric generating plants, the EPA also regulates emissions from major industrial sources, such as cement plants and steel mills, as well as fugitive emissions from oil and gas wells. The Endangerment Finding has led to regulations of carbon-related emissions from these sources and associated increases in costs. It has also led to premature retirements of fossil fuel generating resources and inefficient investments in higher-cost generation, primarily wind and solar power, that require additional backup resources to address their inherent intermittency. Wind and solar power have been boosted owing to federal subsidies (especially investment tax credits) that have been in place since the Energy Policy Act of 1992, which were increased under the Inflation Reduction Act. They have also been boosted by state-level subsidies and mandates requiring that increasing percentages of electricity generated come from renewable resources, as well as mandates to increase the production and usage of costly biofuels.

The result of these programs has been higher prices for electricity, reduced electric reliability, and higher prices for fossil fuel products, such as gasoline and diesel fuel. Higher energy costs have adverse economic consequences because they increase the prices of goods and services, all of which require energy to produce, and higher transportation costs. Those higher costs reverberate through the economy, reducing economic growth by reducing the money available for business expansion and productive investment.

A. Higher Electricity Costs

Fossil fuel electric generating plants are the major stationary sources of CO₂ emissions. Federal regulations, such as the now-defunct Clean Power Plan, as well as state mandates to eliminate fossil fuel generation within the next 10 years (e.g., by 2032 in Oregon and by 2035 in California, New York, and New Jersey), have been a principal cause of rising electric utility rates.

There are a number of reasons for this. First, the premature replacement of older, depreciated plants with new, un-depreciated ones necessarily increases investor-owned electric utilities' cost of service because utilities earn a return solely on the un-depreciated amount of their invested capital.⁷

Second, in regions with organized wholesale electric markets, the premature retirement of fossil fuel generating resources has not been met with the replacement of equivalent generating capacity. For example, according to the PJM Independent Market Monitor, over 58,000 megawatts (MW) of fossil fuel generating capacity is at risk of retirement in the 14-state PJM

⁶ Ted Nordhaus and Alex Trembath, "[The Case for IRA Reform](#)," Breakthrough Institute, February 5, 2025.

⁷ Jonathan A. Lesser and Leonardo R. Giacchino, *Fundamentals of Energy Regulation*, 3d ed., (Dumfries, VA: PUR, 2019).

Interconnection region by 2030, in large part because of environmental regulations.⁸ The reduction in available fossil fuel generation owing to carbon reduction mandates, coupled with rising electric demand, will cause higher wholesale market prices for both energy and capacity resources.

Third, replacing dispatchable fossil fuel generating resources (primarily natural gas-fired that can be scheduled to be turned on or off) with intermittent wind and solar resources requires backup generation and storage to ensure that sufficient electricity is available to meet demand. Because wind and solar generation operate only at limited times throughout the year (i.e., when the sun shines and when the wind blows), each megawatt of fossil fuel generation lost requires replacement with 4–7 MW of wind and solar capacity, plus necessary storage resources, to ensure that there is sufficient electricity available to meet demand at all times. As more intermittent generation is added to the grid, the need for backup generation increases exponentially because there is insufficient reserve capacity. A 2021 study by the New York Reliability Council estimated that to meet the requirements set forth in New York’s Climate Leadership and Community Protection Act (CLCPA), the reserve requirement will need to increase from its current 20% (6,600 MW) to over 100% (50,000 MW) by 2040.⁹ Moreover, New York intends to meet much of that reserve requirement with so-called Dispatchable Emissions-Free Resources (DEFERs), such as generators that burn hydrogen produced from surplus wind and solar power. Such generators do not yet exist.

Fourth, wind and solar generation have low power densities (i.e., capacity per acre) and require tremendous amounts of land. Thus, most wind and solar generation is located in rural areas far from urban load centers (fuse boxes, panel boards, etc.). Delivering the electricity generated thus requires constructing far more high-voltage transmission lines than needed if electric generating plants can be located near load centers. The U.S. Department of Energy has estimated the need for additional transmission capacity.¹⁰ Under this study’s “moderate” growth scenario, the country will need more than 300,000 miles of new transmission capacity by 2040, an average of about 20,000 miles annually. At a cost of several million dollars per mile, the costs could easily exceed \$1 trillion.¹¹

A number of studies have estimated the costs of replacing fossil fuel-based generating systems with systems composed primarily of wind, solar, and storage, along with any existing hydroelectric generation. For example, a recent study of the cost to serve electricity demand in New England estimated that the cost to that region’s ratepayers would be an additional \$815 billion through 2050, resulting in average residential electric bills increasing an average of \$100 per year—each and every year.¹² Another study estimated that the costs of meeting Oregon and

⁸ Monitoring Analytics, [State of the Market Report for PJM 2024](#), March 13, 2025.

⁹ [“Reliability Challenges in Meeting CLCPA Requirements,”](#) New York State Reliability Council, August 2, 2021.

¹⁰ U.S. Dept. of Energy (DOE), [“National Transmission Needs Study,”](#) October 2023.

¹¹ Jonathan A. Lesser, [“Infrastructure Requirements for the Mass Adoption of Electric Vehicles,”](#) National Center for Energy Analytics, June 7, 2024.

¹² Isaac Orr, Mitch Rolling, and Trevor Lewis, [“The Staggering Costs of New England’s Green Energy Policies,”](#) Always On Energy Research, September 2024.

Washington State’s zero-carbon mandates would cost ratepayers an additional \$550 billion and increase average residential rates fivefold.¹³

In addition to higher electricity costs resulting from clean energy mandates, bans on installing natural gas space and water heaters in new construction—and mandates to replace them in existing buildings (e.g., New York City Local Law 97)¹⁴—divert investment from more productive uses and raise the cost of providing heat and hot water.

Similarly, the New York Home Energy Affordable Transition Act (the “HEAT Act”) was reintroduced in that state’s legislature on February 3, 2025.¹⁵ The Heat Act is designed to align gas distribution utility planning and regulation with the state’s CLCPA mandate to eliminate fossil fuel emissions. One aspect of the CLCPA is to eliminate natural gas end-use consumption (e.g., heat and hot water, cooking) for residential and commercial customers. Proponents claim that the HEAT Act will save customers money by avoiding the need to replace aged natural gas lines.¹⁶

However, this ignores the costs of having to increase local distribution system capacity—larger conductors, larger transformers, and higher-capacity substations—to serve the additional load when there is large-scale replacement of natural gas furnaces, boilers, and appliances with electric ones. It also ignores the costs of additional high-voltage transmission system investments needed to deliver electricity from offshore wind facilities and solar facilities located far from load centers. Coupled with New York’s adoption of the California Advanced Clean Car II rules, which increase the percentage of new vehicles sold that must be electric, culminating with a 100% electric vehicle (EV) requirement in 2035, electric loads are likely to double.¹⁷

1. Increased Wholesale Electric Market Price Volatility

In addition to higher wholesale and retail electricity prices, wholesale electricity market prices have become more volatile as wind and solar generating capacity have increased, owing to these technologies’ inherent intermittency.¹⁸ In organized wholesale electric markets, when wind and solar generators are operating, their output displaces conventional generators because resources are selected for dispatch based on their marginal operating costs, which are effectively zero for wind and solar generators. This crowds out traditional generators, such as natural gas-fired plants, that can be cycled on and off. (Typically, base-load coal and nuclear plants cannot be cycled; they must run continuously.) Moreover, the production tax credit, which most wind generators have been eligible for, allows those generators to be profitable even when wholesale

¹³ Jonathan Lesser and Mitchell Rolling, “[The Crippling Costs of Electrification and Net Zero Energy Policies in the Pacific Northwest](#),” Discovery Institute, September 2024.

¹⁴ New York City, [LL97 Greenhouse Gas Emissions Reduction](#) (Local Law 97 of 2019).

¹⁵ The state senate and assembly bills are [S2016](#) and [A4592](#), respectively.

¹⁶ Liz Krueger, “[Senator Liz Krueger Announces Reintroduction of NY HEAT Act](#),” February 3, 2025.

¹⁷ Lesser and Rolling, “[The Crippling Costs of Electrification](#).” Using detailed survey data of EV charging and heat-pump energy use, the authors estimated that full electrification efforts in Washington State and Oregon would double these states’ peak electricity demand.

¹⁸ Jonathan A. Lesser, “[Gresham’s Law of Green Energy](#),” *Regulation* 33 (Winter 2010–11).

market prices fall below zero. When that occurs, base-load plants are forced to pay to continue generating power. As more wind and solar capacity has been added, the number of hours each year during which market prices have been below zero has increased.¹⁹ Coupled with efforts to shut down coal-fired plants, this results in less generating capacity available when wind and solar generators are not producing electricity, causing electricity prices to spike. These impacts have been observed in Europe, too, especially in Great Britain.²⁰

2. Increased Need for Higher-Cost Nonmarket Solutions to Maintain Electric System Reliability

Increased volatility in wholesale electric markets reduces the ability of fossil fuel generators that are needed to maintain electric system reliability and stability (see Section II.B, *infra*) to remain competitive. Consequently, wholesale market operators must resort to nonmarket solutions to ensure that the capacity needed is maintained. These nonmarket solutions, such as “reliability-must-run” (RMR) agreements to prevent a generator from being retired, are costly. For example, Brandon Shores, a 1,300-MW coal-fired power plant located near Baltimore, was slated to close on June 1 of this year, as was the 840-MW H. A. Wagner oil-fired plant, both owned by Talen Energy. Because the plants are needed to maintain reliability, Talen Energy reached an agreement with PJM to continue operating the plants for an additional four years. The additional cost is estimated to be \$720 million.²¹

B. Higher Fossil Fuel Costs

EPA regulations of fugitive emissions from oil and gas wells and gas pipelines directly increase fossil fuel costs. The EPA’s March 8, 2024, New Source Performance Standards (NSPS) rules²² reduced the allowable amounts of fugitive methane emissions (a greenhouse gas) from wells and pipelines to fight climate change.²³ Using updated estimates of the social cost of carbon (SCC), EPA estimated that the rule would provide \$109 billion in climate-related benefits (in present-

¹⁹ Hourly electric market-clearing prices are available from the individual wholesale market operators (such as PJM and SPP). See, e.g., PJM Data Miner 2, [Real-Time Hourly LMPs](#) (locational marginal prices).

²⁰ Eurelectric, “[Understanding Ultra-Low and Negative Power Prices: Causes, Impacts and Improvements](#),” December 2024.

²¹ [H. A. Wagner, LLC and Brandon Shores, LLC, Docket Nos. ER24-187 et al., Protest of Contested Settlement of the Maryland Office of People’s Counsel](#), February 18, 2025.

²² EPA, “[Final Rule to Reduce Methane and Other Harmful Pollution from Oil and Natural Gas Operations](#),” March 8, 2024.

²³ The EPA converts methane emissions, which also occur naturally, into CO₂-equivalent emissions by using a radiative forcing factor of 28. That is, the agency assumes that one molecule of methane has the equivalent warming impact of 28 molecules of CO₂.

value terms), while the present-value costs of compliance would be \$18.8 billion for 2024–38.²⁴ On an annualized basis, EPA estimated that the compliance costs would be \$1.5 billion.²⁵

In addition to raising the costs of oil and gas production, policies designed to combat climate change that have been adopted at the individual state level are increasing fossil fuel costs. Selected states have adopted two types of mandates.

The broadest regulation of carbon-emitting stationary sources has been via the carbon “cap-and-trade” programs that have been adopted in California, Oregon, and Washington State.²⁶ New York State is expected to adopt such a system next year. In addition, 10 states—the six New England states and New York, New Jersey, Maryland, and Delaware—and the District of Columbia belong to the Regional Greenhouse Gas Initiative (RGGI), a carbon cap-and-trade program. The participating states set a cap on annual CO₂ emissions, which decreases over time. Electric generating plants with a capacity of 25 MW are required to purchase “allowances” equal to the amount of CO₂ they emit.²⁷

The impact on the marginal cost of an electric generating plant can be calculated based on its heat rate (i.e., the energy input required to generate 1 MWh of electricity) of affected generators; the higher the heat rate, the greater the cost impact. For example, a modern gas-fired generator with a heat rate of 7.5 million Btus/MWh will emit 877 pounds of CO₂ per MWh. At the most recent RGGI auction price of \$19.76/ton,²⁸ the resulting increase in marginal cost is \$8.67/MWh.

In organized wholesale electric markets, such as those in New England, New York, and the mid-Atlantic states, generators offer their output at their marginal cost. Because natural gas generators are often the marginal resource (i.e., the resource whose supply results in supply matching demand), they set market-clearing prices.²⁹ Consequently, wholesale electric prices increase. In times when demand peaks, such as during extreme cold, natural gas supplies can become constrained, forcing oil-fired generators to operate. Because oil-fired generators are less fuel-efficient and have higher heat rates (typically 11 million–12 million Btus/MWh) and oil emits much more CO₂ per million Btus (160–75 pounds per million Btus), during these extreme peak hours the impact on wholesale electricity prices would be about \$20/MWh.

²⁴ See [“Regulatory Impact Analysis of the Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review,”](#) EPA-452/R-23-013, December 2023, Tables 1-4 and 1-5. The values reflect the sums for rules EG OOOOb and EG OOOOc.

²⁵ Values are those reported for a 2% discount rate, consistent with the discount rate used to value carbon emissions reductions.

²⁶ California Air Resources Board, [“Final Regulation Order, California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms,”](#) April 1, 2019; State of Washington, Climate Commitment Act, [SB 5126—2021–22](#).

²⁷ See [RGGI Factsheet](#), undated.

²⁸ RGGI, [“CO₂ Allowances Sold for \\$19.76 in 67th RGGI Auction,”](#) March 14, 2025.

²⁹ In 2023, for example, E.g., gas-fired generators set market prices in 60% of all hours in New England.

Three states—California, Oregon, and Washington State—have adopted broader CO₂ cap-and-trade programs that affect not just electric generators but all fossil fuel usage. New York has indicated its intent to adopt a cap-and-trade program, although it remains unclear when the program will start.³⁰ These state programs limit (cap) the amount of CO₂ emissions that can be released for all fossil fuel consumption. (Agricultural sources, such as diesel fuel for tractors, have generally been exempted.) These broader state programs require natural gas utilities, industrial facilities, and retail sellers of fossil fuels (e.g., gasoline, fuel oil, and propane dealers) to obtain allowances for all fossil fuels they sell to consumers.

As with RGGI, under these programs, a specific quantity of CO₂ allowances is auctioned periodically. Large stationary emitters must purchase sufficient CO₂ allowances to cover their total emissions. Emitters that can reduce their emissions below those levels may sell the surplus allowances to other emitters that cannot reduce their emissions at costs below the market price of allowances, similar to the EPA’s cap-and-trade system for sulfur dioxide and oxides of nitrogen that was established under the 1990 Clean Air Amendments.

In the first year of Washington State’s program, the impact on the average price of gasoline and diesel fuel is disputed, with some estimates claiming that the impact has been 40–45 cents/gallon, while other estimates are lower.³¹ The most recent clearing price for allowances is \$50/ton.³² Because the state program excludes ethanol that is mixed with gasoline, the current allowance price translates into a tax of about 45 cents/gallon.³³ The implied tax on diesel fuel and heating oil is higher, given those fuels’ higher CO₂ content, translating into an implied tax of about 56 cents/gallon.

Higher energy costs—whether fossil fuels or electricity—are inflationary. All goods and services produced in the economy require energy as an input. When the cost of energy increases, so do production costs. As history shows, inflation imposes real costs on societies, in terms of reductions in the standard of living, greater economic uncertainty and less investment, and social disintegration.

³⁰ The New York Dept. of Environmental Conservation has released draft regulations for the program; see “[Recently Proposed and Adopted Regulations and Policies](#),” undated.

³¹ Brian C. Prest, “[Feedbacks Between Emissions Markets and Political Outcomes: A Case Study of Washington State’s Cap-and-Trade Program](#),” *Resources*, March 21, 2024.

³² Washington State Dept. of Ecology, “[Auction #9 Summary Report](#),” March 12, 2025.

³³ According to the U.S. Energy Information Administration (EIA), [Carbon Dioxide Emissions Coefficients](#), September 18, 2024, the CO₂ content of gasoline is 20.86 pounds per gallon and 22.45 pounds per gallon for diesel fuel and home heating oil. At a price of \$50/ton, and assuming consumers bear the full cost of the tax based on inelastic demand for gasoline, the cost per gallon is: (20.86 pounds/gallon) / (2000 pounds/ton) × \$50/ton = \$0.52/gallon. Because gasoline is blended with 10% ethanol, which is exempt from the tax, the overall impact is then (1 – 10%) × \$0.52 = \$0.47/gallon. A similar calculation applies to diesel fuel, although those are not mixed with ethanol.

C. Decreases in Grid Reliability and Stability

Two interrelated but distinct attributes of an electric power grid are reliability and stability. Generally, an electric system is reliable if sufficient electricity can be generated and delivered to meet demand. That requires ensuring that there is sufficient reserve capacity to meet unexpected outages of individual generators or high-voltage transmission lines. Stability requires frequency and voltage levels to be maintained within strict limits. If either strays beyond those limits, blackouts can result.

Increased reliance on intermittent renewable generation resources increases the need for fossil fuel backup to maintain reliability, especially natural gas generators that can be quickly brought online. This situation has developed in Germany, despite a decrease in overall reliance on natural gas for electricity. The reason: a greater need for backup generation when wind and solar are unavailable.³⁴

As laws and regulations have forced grid operators to incorporate greater renewable generation into their portfolio mix, concerns about the reliability and stability of these power grids have intensified. The question is not whether a renewable-majority grid can in theory be constructed and operated, but the practical and economic limitations of doing so without undermining reliability and stability. For example, in a 2021 report, the New York State Reliability Council estimated that meeting that state's zero-emission electricity goal by 2040 will require increasing the reserve margin from its current 20% level to over 100%.³⁵ In effect, backup generating capacity greater than peak demand will be required to compensate for wind and solar generation's inherent intermittency. The additional backup generating capacity to ensure reliability means higher-cost electricity.

Electric system stability requires balancing supply and demand at all times. To generate electricity, coal, natural gas, hydropower, and nuclear power all spin large turbines that induce an alternating current through the principles of electromagnetism. These systems are rooted in physical movement, which provides the rotational inertia that protects the grid from threatening interruptions and also provides power at a constant frequency.

By contrast, solar and wind generation is intermittent and provides no inertia without specialized equipment. It also requires inverters that convert direct current electricity to alternating current. (That conversion process results in additional energy losses.) A report by Idaho National Laboratory described the three “defining characteristics” of renewable sources as inverter-based, intermittent, and “not dispatchable, meaning that the renewables’ electric output cannot be provided on demand.”³⁶ A 2021 analysis by Brookhaven National Laboratory further explained: “The rapidly increasing penetration of intermittent renewables such as solar and wind causes a rising concern with the performance of grid frequency response, especially under light load conditions. Large power mismatches caused by high fluctuations of renewables may further

³⁴ Energy Charts, [Net Installed Electricity Generating Capacity in Germany](#), accessed April 28, 2025.

³⁵ See *supra*, note 9.

³⁶ Jake Gentle et al., *Voltage Optimization*, [INL/RPT-24-80255](#), Idaho National Laboratory (November 2024), 1.

exacerbate grid inertial responses. Loss of inertia is thus a grave concern to grid operators.”³⁷ Current battery technology can help alleviate these challenges, but only for a few hours at a time.

Electric network operators compensate for fluctuations in grid voltage and frequency by providing “regulation service,” which allows generators to be ramped up or down quickly to match supply and demand. In addition, these networks must ensure that there is the proper amount of reactive power on the grid, which maintains voltage levels.³⁸

A 2022 analysis on the problem of electric grid blackstarts (i.e., restoring power after it has been completely lost) warned that “system-wide blackouts” could result from the lack of potential inertia without “significant changes in power system operational practices.”³⁹ The April 28, 2025, blackout affecting Spain, Portugal, and France may have been caused by this lack of inertia, as Spain’s state electricity network operator Red Eléctrica observed “very strong oscillations” in the electric network, which had been relying primarily on solar power immediately before disconnecting from the larger European grid.⁴⁰

The frequency of both weather-related and non-weather-related outages in the U.S. has increased over the last two decades, and especially since 2020, with their attendant costs.⁴¹ Those costs are measured based on the “value of lost load” (VOLL) and are typically expressed in dollars per kilowatt-hour (\$/kWh). The simplest measure of VOLL is GDP divided by total electricity consumption. In 2024, for example, U.S. GDP was approximately \$29.4 trillion, and U.S. electric sales totaled 3,962 terawatt-hours, implying an average VOLL of \$7.42/kWh. This represents a lower-bound value based on the assumption that the economic value of electricity used must exceed its cost. In other words, if consumers are willing to purchase electricity, they must place a higher value on that electricity than the price they pay. Estimates of VOLL show

³⁷ Meng Yue et al., “[Stochastic Sizing and Operation of Grid-Level Energy Storage Systems Under Intermittent Renewable Generation and Increasing Load Forecasting Uncertainties](#),” Brookhaven National Laboratory (July 31, 2021), 1. See also Njabulo Mlilo, Jason Brown, and Tony Ahfock, “[Impact of Intermittent Renewable Energy Generation Penetration on the Power System Networks—A Review](#),” *Technology and Economics of Smart Grids and Sustainable Energy*, December 10, 2021; Hasan Eroğlu et al., “[Harmonic Problems in Renewable and Sustainable Energy Systems: A Comprehensive Review](#),” *Sustainable Energy Technologies and Assessments*, December 2021.

³⁸ Reactive power is one of six ancillary services defined by the Federal Energy Regulatory Commission in its [Order No. 888](#). For a detailed discussion of ancillary services in PJM, see Monitoring Analytics, [2024 State of the Market Report for PJM, Section 10](#), March 13, 2025.

³⁹ James G. O’Brien et al., *Electric Grid Blackstart: Trends, Challenges, and Opportunities*, Pacific Northwest National Laboratory, [PNNL-32773](#) (April 2022), 3.

⁴⁰ David Averre and James Reynolds, “[Blackout Chaos: Could Renewable Energy Be to Blame for Huge Spain Blackout? How Outage Struck Days After Country’s Grid Ran Entirely on Green Power for the First Time](#),” *Daily Mail*, April 28, 2025.

⁴¹ DOE, [DOE OE-417 Annual Summaries](#).

that consumers value electricity highly. Increasing societal dependence on electrification means that the value of not having access to electricity when needed becomes more costly.⁴²

Technology exists to mitigate some of these concerns about reliability, but these solutions are costly and will increase the costs of grid deployment and maintenance. That, in turn, will raise electricity prices. The Department of Energy’s most recent grid modernization strategy, for example, highlighted the need for “basic and applied R&D to realize more flexible, modular, and efficient power electronics materials, devices, and controls” to integrate more renewables into the grid.⁴³ The call for greater R&D funding is an implicit admission that these problems have not been solved.

D. Reduced Economic Growth Because of Higher Energy Prices

The 1974 OPEC oil embargo demonstrated the link between energy costs and economic growth.⁴⁴ The same is true today of higher electricity and fossil fuel costs. Moreover, given the increasing electrification of the U.S. economy, higher electricity costs caused by substituting wind and solar power for fossil fuel (and nuclear) generation will have an increasing impact on the macroeconomy. Higher energy costs increase the cost of all goods and services because *all* goods and services require energy as an input to their production.⁴⁵ This leads to reductions in consumer welfare as the effects of those higher costs reverberate through the economy.

Furthermore, higher energy prices have led to deindustrialization, as energy-intensive industries are unable to remain competitive owing to high energy costs. Several European countries—notably, Germany and Great Britain—have experienced these impacts.⁴⁶ The impacts extend beyond just reduced economic growth, such as lost jobs; they extend to adverse impacts on human health and welfare that are associated with reduced economic growth.⁴⁷

⁴² Jonathan Lesser, “[Electrification Without Electricity: An Epic Failure in Planning for Critical Infrastructure](#),” National Center for Energy Analytics, January 22, 2025.

⁴³ DOE, [Grid Modernization Initiative 2024](#) (July 2024), 15.

⁴⁴ See, e.g., Benjamin Hunt, Peter Isard, and Douglas Laxton, “[The Macroeconomic Effects of Higher Oil Prices](#),” International Monetary Fund, Working Paper 2001/014, January 2001; Donald W. Jones, Paul N. Leiby, and Inja K. Paik, “[Oil Price Shocks and Macroeconomy: What Has Been Learned Since 1996?](#)” *The Energy Journal* (April 2004).

⁴⁵ Kuo S. Huang and Sophia Wu Huang, “[Consumer Welfare Effects of Increased Food and Energy Prices](#),” *Applied Economics*, May 3, 2011; Stefan F. Schubert and Stephen J. Turnovsky, “[The Impact of Energy Prices on Growth and Welfare in a Developing Open Economy](#),” *Open Economies Review*, March 19, 2011; Paul H. Templet, “[Energy Price Disparity and Public Welfare](#),” *Ecological Economics*, March 2001; Silvia Tiezzi, “[The Welfare Effects and the Distributive Impact of Carbon Taxation on Italian Households](#),” *Energy Policy*, August 2005.

⁴⁶ Hilary Schmidt, “[Germany Has an Escalating Deindustrialisation Problem](#),” *International Banker*, January 28, 2025; Mario Loyola, “[High Electricity Prices Have Europe Facing Deindustrialization; Don’t Let It Happen Here](#),” *The Hill*, January 28, 2024.

⁴⁷ Bjorn Brey and Valeria Rueda, “[The Persistent Human Costs of Deindustrialization: Lessons from the Collapse of the British Coal Industry](#),” VOX^{EU}, September 1, 2024.

Fossil fuels have been the main driver of industrialization, economic growth, and higher living standards for the past 200 years. There is a direct correlation between per-capita fossil fuel consumption and per-capita income levels.⁴⁸ Using an emissions test to limit the production and consumption of fossil fuels will shrink national wealth.

Ramping up renewable power will increase the exposure of the American power grid to weather-related disruptions and decrease system reliability. It will also drive up the average cost of U.S. electricity, given that wind and solar power are the most expensive forms of electricity on a levelized cost basis when subsidies are stripped out and backup and storage are added back in.

Constraining the domestic production of fossil fuels will lead to higher oil and gas prices, which, in turn, will feed through the entire U.S. economy and raise the cost of almost everything (especially food). Given that hydrocarbons are used to make, transport, or facilitate almost every good or service in the American economy, the ripple effects of a supply-driven increase in oil and gas prices will be pronounced. Hand in hand with higher general price inflation, curtailing domestic oil and gas production will also lead to significant job losses and a shrinking economy.

Germany's recent decline shows the economic downside of prioritizing climate over sound energy policy. Since embarking in 2016 on its Climate Action Plan 2050, Germany has banned oil and gas drilling using hydraulic fracturing (fracking) technology, replaced base-load coal and nuclear power plants with intermittent wind and solar generation, and done little to secure its natural gas supply chain since losing access to Russian pipeline imports when war broke out in Ukraine in February 2022. Over the past decade, Germany, the largest economy in Europe, has experienced a downward spiral of deindustrialization and degrowth. German industrial production peaked in 2017,⁴⁹ real GDP growth averaged only 1.2% over 2012–22,⁵⁰ and the country has been mired in recession since 2023.⁵¹ German corporate bankruptcies and unemployment levels continue to rise, and GDP per capita has stagnated since 2015.

1. Economic Losses from Declining Manufacturing and Mining Activity

The decline of mining, mineral processing, and energy-intensive manufacturing in the U.S. over the last several decades can be attributed to policies meant to discourage the use of hydrocarbons in an effort to reduce carbon dioxide emissions. This transparent policy aim is seen most clearly in the 2024 EPA rules applying to electric power generation plants,⁵² but a wide swath of industrial regulations has been aimed at reducing “carbon pollution” across industrial sectors.

Significant economic growth has gone unrealized due to regulations penalizing industries that traditionally rely heavily on hydrocarbon fuels for manufacturing their products. The decline of

⁴⁸ Our World in Data, “[Per Capita Fossil Fuel Energy Consumption vs. GDP Per Capita, 2023](#),” accessed April 18, 2025.

⁴⁹ German Federal Statistical Office, “[Indices of Production in Manufacturing](#),” accessed April 18, 2025.

⁵⁰ Ibid., “[Gross Domestic Product Down 0.3% in 2023](#),” January 15, 2024.

⁵¹ Ian King, “[Germany: Europe’s Largest Economy Is Facing a Third Consecutive Year of Recession](#),” *Sky News*, January 16, 2025.

⁵² EPA, “[Biden-Harris Administration Finalizes Suite of Standards to Reduce Pollution from Fossil Fuel-Fired Power Plants](#),” April 25, 2024.

these domestic industrial sectors can be measured in reduced gross output that contributes to GDP, a growing negative trade balance for energy-intensive commodities and products over the last 25 years, and lost employment from these industries.

Data from the Bureau of Economic Analysis (BEA) breaks down gross output contributions to GDP by industry, which allows analysis of trends in energy-intensive industries.⁵³ Had these industries' share of gross output not declined from their 2007 values, the result would have been an additional \$6.7 trillion in U.S. GDP in 2024.⁵⁴

Employment data from BEA for the primary metal industries and the industrial machinery sectors each show a fall of ~47% between 2000 and 2023 in the number of full-time-equivalent employees.⁵⁵ This translates to 328,000 jobs lost in primary metals and 974,000 jobs lost in the industrial machinery sector. Despite increases in domestic output over the period, employment in these key energy-intensive manufacturing sectors fell dramatically, leading to a weakening of the industrial base in the United States. European countries that have aggressively embraced CO₂-neutral policy goals that favor renewable energy technologies and discourage energy-intensive hydrocarbon-based manufacturing have deindustrialized even more precipitously.⁵⁶

Moreover, the loss of manufacturing jobs has a well-known “multiplier effect,” causing losses in businesses that supply inputs to manufacturing companies and businesses that rely on spending by their employees. This is not the same as automation-related losses, which can result in increased economic efficiency and lower production costs. Rather, it reflects the adverse impacts of higher-cost energy supplies that lead to deindustrialization.

One effect of decades of aggressive policy efforts in California to downsize its fossil fuel industry was that, in 2023, foreign suppliers such as Iraq and Saudi Arabia accounted for over 60% of the state's petroleum supply, compared with 10% in 1996. A further effect of the continued decline in the state's fossil fuel industry has been the loss of 300,000 generally high-paying jobs.⁵⁷

Data on trade in energy-intensive products are from the World Integrated Trade Solution (WITS) database.⁵⁸ The World Bank shows a steady rise in net imports of energy-intensive goods into the U.S. over the last decade. Trade deficit data for ores and metals, chemical products, and

⁵³ EIA classifies [energy-intensive industries](#) as including: mining (including oil and natural gas extraction), nonmetallic minerals (e.g., cement, glass), metals (e.g., iron and steel, copper, tin), fabricated metal products, machinery, petroleum refining, food manufacturing, and basic chemicals.

⁵⁴ U.S. Bureau of Economic Analysis (BEA), [GDP by Industry](#), accessed April 6, 2025.

⁵⁵ Ibid., [National Income and Product Accounts](#), sec. 6, Income and Employment by Industry, accessed April 6, 2025.

⁵⁶ Thomas Obst, “Europe on the Brink of Recession? Economic Challenges and Dangers of Deindustrialization,” in *Economic Policy in an Unstable Environment*, ed. Jürgen Wandel, Andreas Bielig, and Katarzyna Kamińska (Warsaw: SGH, 2023), 15–33.

⁵⁷ Joel Kotkin, “[Climate Change Driving California's Golden Road to Decline](#),” RealClearInvestigations, April 3, 2025.

⁵⁸ World Bank, [World Integrated Trade Solution \(WITS\)](#).

machinery show deficits totaling over \$25 billion, \$100 billion, and \$520 billion, respectively, in 2022. These deficits represent increases of over 750%, 250%, and 460%, for ores and metals, chemical products, and machinery, respectively, from 2011 to 2022.

2. Economic Losses to Commercial and Recreational Fisheries

The expansion of offshore wind farms (OWFs) has been a key component of policies aimed at reducing CO₂ emissions in the United States. This ocean-based activity requires the establishment and maintenance of extensive physical infrastructure in the ocean that affects existing commercial activity, primarily with turbines and underwater cables. The consequences of this newly introduced ocean infrastructure include restricted access to high-value fishing areas, navigation around wind areas, and the crowding of alternative fishing locations as a consequence of displacement.⁵⁹

The northeastern coast of the U.S., including New England and the mid-Atlantic states, has seen the most activity in the development of OWFs and also hosts a considerable commercial fishing industry.

According to the National Marine Fisheries Service, the New England commercial seafood industry in 2022 generated about 290,000 jobs, \$28.5 billion in sales, \$7.0 billion in income, and \$10.9 billion in added value. The mid-Atlantic commercial seafood industry supported about 204,000 jobs and generated over \$30 billion in sales, \$6.4 billion in income, and \$10.6 billion in added value.⁶⁰

The introduction of OWFs has the potential to interfere with the continued success of the commercial seafood industry in several ways. The National Oceanic and Atmospheric Administration (NOAA) states⁶¹ that the construction and operation of wind turbines could affect commercial, recreational, and tribal fishing in a variety of ways, including:

- Displacing fishermen from traditional fishing areas
- Changing the distribution, abundance, and species composition of fish in an area
- Increasing vessel traffic and competition for support services onshore
- Increasing and consolidating vessel traffic offshore
- Increasing operational costs
- Disrupting vessel radar systems
- Damaging or destroying fishing gear

⁵⁹ S. Mackinson et al., "[A Report on the Perceptions of the Fishing Industry into the Potential Socio-Economic Impacts of Offshore Wind Energy Developments on Their Work Patterns and Income](#)," Centre for Environment, Fisheries & Aquaculture Science, U.K., October 2006.

⁶⁰ National Oceanic and Atmospheric Administration (NOAA), [Fisheries Economics of the United States 2022](#), NOAA Technical Memorandum NMFS-F/SPO-248b, November 2024.

⁶¹ NOAA, [Offshore Wind Energy: Evaluating Impacts to Fisheries](#), accessed April 6, 2025.

- Reducing safety at sea from increased vessel traffic and navigation challenges, including radar interference.⁶²

In attempting to quantify the economic impacts of OWFs on fishing industries, a 2023 review⁶³ considered four main impacts: fuel expenditures; insurance costs; fishing industry revenues, income, and livelihoods; and fishing support businesses. Fuel usage accounts for about 80% of at-sea operational costs for commercial fishing vessels in the greater Atlantic region.⁶⁴ Based on a 2014 study, the rerouting caused by offshore wind development increased per-transit distances by 18.5 kilometers and cumulative annual industry costs by \$9.76 million, mostly from added fuel.⁶⁵

Besides the added costs associated with the physical disruptions caused by OWF development and operations, OWFs have the potential to impose direct loss of revenue to commercial fishers due to reduced ocean harvests. The New England and mid-Atlantic commercial fisheries each generate over \$3 billion in income and \$5 billion in added value annually. Looking at selected fishery landings that overlapped with currently approved lease areas (as of February 2025), NOAA estimates the total commercial fishing revenue from lease areas over the last 16 years at ~\$660 million⁶⁶ during 2008–23, or an average of \$44 million/year.

The effects of this revenue loss are distributed across species and locations along the northeastern coast of the United States. The top 10 species affected by revenue are scallops, clams, squid (*Loligo*), lobster, flounder, summer fish (e.g., blue gill, red snapper), pollock, sea bass, blackfish, and haddock.

The fishery for Atlantic surf clams (*Spisula solidissima*) is particularly vulnerable to impacts from offshore wind energy development because of the overlap of its fishing grounds with lease areas.⁶⁷ The Atlantic surf clam fishery is a key economic driver for communities from Virginia to

⁶² National Academies of Science, Engineering, and Medicine, *Wind Turbine Generator Impacts to Marine Vessel Radar* (Washington, DC: National Academies Press, 2022).

⁶³ Marina Chaji and Samantha Werner, “[Economic Impacts of Offshore Wind Farms on Fishing Industries: Perspectives, Methods, and Knowledge Gaps](#),” *Marine and Coastal Fisheries*, June 4, 2023.

⁶⁴ Chhandita Das, “[Northeast Trip Cost Data—Overview, Estimation, and Predictions](#),” NOAA Technical Memorandum NMFS-NE-227, November 2013.

⁶⁵ Kateryna Samoteskul et al., “[Changing Vessel Routes Could Significantly Reduce the Cost of Future Offshore Wind Projects](#),” *Journal of Environmental Management*, August 1, 2014.

⁶⁶ [Descriptions of Selected Fishery Landings, Revenues, and Effort from Currently Approved Lease Areas and Export Cable Routes: A Planning-Level Assessment](#), National Marine Fisheries Service, February 27, 2025.

⁶⁷ A. Kirkpatrick et al., *Socio-Economic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic*, Bureau of Ocean Energy Management, Atlantic Outer Continental Shelf Region, OCS Study BOEM 2017-012, [Vol. 1: Report Narrative](#) and [Vol. 2: Appendices](#).

Massachusetts, generating over \$30 million in annual landings revenue.⁶⁸ For all these species, there is a large output multiplier (i.e., total economic output relative to landing revenues). From 2013 to 2017 for all regional U.S. longfin inshore squid landings, the output multiplier was 7.64 (i.e., every dollar in landings led to \$7.64 in additional total economic output).⁶⁹

The effects of OWF development often arise from conflicts with future marine spatial planning and therefore can cause disruptions in the planning stages well before the actual installation of OWFs at sea. This means that areas going up and down the East Coast of the U.S., including those with little current construction activity, are directly affected by OWF development plans. Any potential impacts will be felt most severely in New Jersey and Massachusetts, which account for two-thirds of all commercial fishery revenue, with impacts felt in Virginia to the south and Maine to the north.

Finally, aside from the potential costs borne by commercial and recreational fisheries, the development, installation, and maintenance of OWFs cause acoustic disruptions to the ocean environment from the surface down to the seabed. While several studies have documented the effects of OWFs on marine species,⁷⁰ researchers have yet to fully characterize this threat to ocean ecosystems from noise, with much of the effect on marine life remaining unknown.⁷¹

E. Increased Crowding Out of Private Capital Available for Productive Investment

The Endangerment Finding labeling greenhouse gas emissions as regulated air pollutants has been used to justify financial regulations aimed at redirecting investment away from the fossil fuel industry and toward low-carbon sources of energy such as wind and solar power. The main goal of the SEC's ESG (environmental, social, and corporate governance) regulations is to leverage the private financial markets to help force an energy transition away from crude oil, natural gas, and coal. Basing investment decisions on climate and other nonpecuniary ESG factors will lead to market distortions, economic inefficiencies, and a misallocation of capital, since regulators will essentially be overruling the market's normal pricing and clearing function. Since 2015, there has been a sharp shift in U.S. investment flows toward clean energy projects

⁶⁸ Sarah Borsetti et al., "[Potential Repercussions of Offshore Wind Energy Development in the Northeast United States for the Atlantic Surfclam Survey and Population Assessment](#)," *Marine and Coastal Fisheries*, February 27, 2023.

⁶⁹ Andrew M. Scheld, "[Economic Impacts Associated with the Commercial Fishery for Longfin Squid \(*Doryteuthis pealeii*\) in the Northeast U.S.](#)," Virginia Institute of Marine Science, 2018.

⁷⁰ Uwe Stöber and Frank Thomsen, "[How Could Operational Underwater Sound from Future Offshore Wind Turbines Impact Marine Life?](#)" *Journal of the Acoustical Society of America*, March 15, 2021.

⁷¹ Arthur N. Popper et al., "[Offshore Wind Energy Development: Research Priorities for Sound and Vibration Effects on Fishes and Aquatic Invertebrates](#)," *Journal of the Acoustical Society of America*, January 11, 2022.

despite their lower return profile. In 2024, total U.S. clean energy investment (\$300 billion) eclipsed fossil fuel capital spending (\$197 billion) by 50%.⁷²

Climate-focused ESG regulations (such as the SEC’s recently rescinded climate disclosure rules) are designed to raise the cost of capital for the traditional energy sector and ultimately to shut off market access for these companies. The bank loan and corporate bond markets are the main targets of these discriminatory rules, given the reliance of the capital-intensive fossil fuel industry on less expensive debt for organic and acquisition-related growth. Wider credit spreads due to a regulator-mandated climate risk premium will lead to higher oil and gas company borrowing costs, as will a general increase in underlying Treasury rates.

In the latter case, significant government spending to support and promote less efficient renewable energy sources has exacerbated the federal deficit and increased outstanding public debt (\$36.2 trillion as of the fourth quarter of 2024, the equivalent of 121.9% of GDP).⁷³ This, in turn, has led to increased Treasury borrowing and higher benchmark interest rates to clear more frequent government bond and bill auctions. The budgetary cost of the 2022 Inflation Reduction Act, which was mainly a climate bill comprising myriad long-lived clean energy tax credits, has been estimated by the Cato Institute at upward of \$4.7 trillion through 2050.⁷⁴ Forced expenditures on low- and negative-return investments, including offshore wind, carbon capture and storage, and production of “green” hydrogen, divert capital from more productive investments.

F. Increased National Security Risks

Allowing carbon emissions goals to drive national energy policy will put the U.S. at a distinct economic disadvantage against other nations not bound by the same climate rules, particularly China, the world’s second-largest economy and America’s main commercial rival and geopolitical adversary. Decarbonization will lead to higher energy and electricity prices and a destabilized power grid, weakening the competitive position of domestic manufacturing and heavy industry and accelerating the globalization-driven offshoring trend of the past 25 years. Transitioning the U.S. economy to clean energy will make the country more dependent on China for everything from electric vehicles (EVs) to solar panels to critical and rare earth minerals.⁷⁵

It will also heighten national security risks by limiting America’s ability to project political strength and military might at a critical time in world history. Electrifying the entire U.S. economy while increasing its reliance on intermittent wind and solar power, as well as less efficient transportation fuels such as biodiesel, will lead to diminished and more volatile GDP growth and lower average living standards. Weaker economies without a reliable supply of fossil fuel energy and a strong

⁷² International Energy Agency (IEA), “[World Energy Investment 2024](#),” accessed April 17, 2025.

⁷³ Federal Reserve Bank of St. Louis, Economic Research, “[Federal Debt: Total Public Debt](#),” June 2024, accessed April 16, 2025.

⁷⁴ Travis Fisher and Joshua Loucks, “[The Budgetary Cost of the Inflation Reduction Act’s Energy Subsidies](#),” Cato Institute, March 11, 2025.

⁷⁵ Teresa Mull, “[The US Is Greening Itself Toward More Dependence on China](#),” *The Spectator*, April 7, 2023.

domestic industrial base cannot maintain an adequate military fighting force or wage war on a sustained basis. Carbon-free countries cannot generate the economic growth and budgetary resources needed to defend themselves or other parts of the world. Government subsidies for uneconomic clean energy, in short, divert scarce public-sector funding from critical budget areas such as defense.

The recent experience of Germany and other industrialized European countries illustrates this point. Europe aspires to be the first carbon-free continent on the planet by 2050 and has implemented aggressive net-zero policies since 2015 to restructure its regional economy away from carbon-emitting fossil fuels.⁷⁶ Many European NATO member states have struggled over the past decade to keep up with their defense spending commitments (2% GDP),⁷⁷ while Europe's ability to provide ongoing financial and military support to Ukraine in its war against Russia over the past three years has been severely challenged by defense spending deficiencies, exacerbated by a homegrown energy crisis.⁷⁸

1. Costs of Managing Greater Vulnerability to Crude Oil Disruptions

The Strategic Petroleum Reserve (SPR), a network of salt caverns filled with crude oil managed by the U.S. Department of Energy in Louisiana and Texas, exists to supply domestic energy in the event of supply disruptions and emergencies. Much of that crude oil is produced domestically; but historically, much has also been imported. To the extent that policies impose or otherwise result in depressed domestic oil production, the SPR becomes more important, not less.

If oil is not produced domestically, it must be imported. If it is imported, its transportation and delivery take time. During a supply crisis, the SPR can deliver crude oil to the market comparatively much quicker than seaborne transportation from overseas supply centers. In FY 2024, the SPR cost \$207 million to operate, but the FY 2025 request stood at \$241 million and is projected to increase through FY 2029 to \$264 million. It is important to note that none of these numbers includes the cost of the crude oil itself. These dollar amounts concern only maintenance activities, cavern and pipeline integrity, and construction projects. Crucially, the largest-ever withdrawals from the SPR occurred in response to Russia's invasion of Ukraine in 2022. The U.S. Energy Information Administration (EIA) reported earlier this year that Europe was the top regional destination for U.S. crude oil exports in 2023 and 2024.⁷⁹ Europe is widely known for having adopted even stricter policies against greenhouse gas emissions and fossil fuel usage than the United States.

G. Adverse Health and Property-Value Impacts of Wind Turbines

Of all forms of renewable generation, wind power is the largest in terms of installed capacity. According to the EIA, as of February 1, 2025, there were over 153,000 MW of installed wind

⁷⁶ European Commission, "[2050 Long-Term Strategy](#)," accessed April 18, 2025.

⁷⁷ North Atlantic Treaty Organization, "[Defence Expenditure of NATO Countries \(2014–2024\)](#)," accessed April 18, 2025.

⁷⁸ Max Bergmann, "[Europe Needs a Paradigm Shift in How It Supports Ukraine](#)," Center for Strategic & International Studies, January 17, 2024.

⁷⁹ EIA, "[Petroleum Exports by Destination](#)," April 30, 2025.

generation.⁸⁰ Wind turbines emit sounds at frequencies that can be heard by humans (between 20 and 20,000 hertz) and sounds at frequencies below the 20-hertz threshold. Wind turbine noise is associated with sleep disruption and other adverse health impacts and a general reduction in the quality of life.⁸¹

Additionally, the sale prices of properties located near wind turbines (both onshore and offshore) suffer a decline relative to properties not so located.⁸² The loss of property values can be classified as a pecuniary externality because the lost value can be measured directly. Reduced property values also propagate throughout local communities in the form of reduced property taxes, which are typically tied to assessed values.

As states mandate additional wind generation, through renewable portfolio standards or direct mandates, a greater portion of the population will be adversely affected.

H. Loss of Biodiversity and Agriculture from Wind and Solar Development

1. Increased Animal Fatalities

One study published in 2021 estimated a rate of 1.2 trillion insects killed by wind turbines per year in Germany, assuming an insect body mass of 1 milligram, with a single wind turbine in a temperate zone capable of killing 40 million insects per year. A study the following year found that old wind turbines operating without restrictions have killed bats colliding with the wind turbines. For two months, a wind park with three turbines west of Berlin has caused more than 70 fatalities per turbine, or 39 fatalities per MW.⁸³

⁸⁰ EIA, *Electric Power Monthly*, [Table 6.1: Electric Generating Summer Capacity Changes \(MW\), January 2025 to February 2025](#), March 2025.

⁸¹ See, e.g., Mariana Alves-Pereira and Nuno A. A. Castelo Branco, "[Vibroacoustic Disease: Biological Effects of Infrasound and Low-Frequency Noise Explained by Mechanotransduction Cellular Signalling](#)," *Progress in Biophysics and Molecular Biology* 93, nos. 1–3 (January–April 2007); Roy D. Jeffery, Carmen M. E. Krogh, and Brett Horner, "[Industrial Wind Turbines and Adverse Health Effects](#)," *Canadian Journal of Rural Medicine*, May 2013; Michael A. Nissenbaum, Jeffery J. Aramini, and Christopher D. Hanning, "[Effects of Industrial Wind Turbine Noise on Sleep and Health](#)," *Noise & Health* (September–October 2012); Daniel Shepherd et al., "[Evaluating the Impact of Wind Turbine Noise on Health-Related Quality of Life](#)," *Noise & Health* (September–October 2011); Asli Ata Teneler and Hur Hassoy, "[Health Effects of Wind Turbines: A Review of the Literature Between 2010–2020](#)," *International Journal of Environmental Health Research*, December 2, 2021.

⁸² See, e.g., Cathrine Ulla Jensen et al., "[The Impact of On-Shore and Off-Shore Wind Turbine Farms on Property Prices](#)," *Energy Policy*, May 2018; Stephen Gibbons, "[Gone with the Wind: Valuing the Visual Impacts of Wind Turbines Through House Prices](#)," *Journal of Environmental Economics and Management*, July 2015; Marvin Schütt, "[Wind Turbines and Property Values: A Meta-Regression Analysis](#)," *Environmental and Resource Economics*, December 2023.

⁸³ Christian C. Voigt, "[Insect Fatalities at Wind Turbines as Biodiversity Sinks](#)," *Conservation Science and Practice*, January 6, 2021; idem et al., "[Wind Turbines Without Curtailment Produce Large Numbers of Bat Fatalities Throughout Their Lifetime: A Call Against Ignorance](#)

Likewise, a study in 2022 found that wind and solar energy systems in California exact a toll on the population of various bird species. Fatalities may be caused by collisions with wind turbine blades, photovoltaic panels, or heliostat solar reflectors; by concentrated beams of sunlight at solar power towers; by grounding at solar power plants; or by drowning in wastewater evaporation ponds at concentrating solar power plants.⁸⁴

2. Forgone CO₂ Fertilization Benefits

In addition to affecting the radiative properties of Earth's atmosphere (the greenhouse effect), the concentration of CO₂ in the atmosphere influences the growth of terrestrial vegetation. CO₂ in the atmosphere plays an essential role in the global carbon cycle that relies on the transport of carbon between land, air, and sea. For plants, the increase in CO₂ contributes significantly to enhanced growth and improved water-use efficiency. Far from being a pollutant, CO₂ is essential to all life on the planet.

The benefits of increased CO₂ concentrations for plants have been known for centuries. Today, professional horticulturalists around the world typically maintain CO₂ concentrations of 1,000–1,200 parts per million (ppm) in their greenhouses to promote the growth of plants. Globally, greenhouses consume over 500 million tons of CO₂ annually.⁸⁵

Outside of greenhouses, the concentration of CO₂ in the atmosphere is 425–430 ppm (as of March 2025).⁸⁶ While current levels of CO₂ enrichment in the atmosphere fall well short of those found in greenhouses, the small annual rise in CO₂ over the last two centuries has increased the availability of this essential nutrient to plants around the globe.

Based on satellite data, according to NASA, the effect of atmospheric carbon dioxide enrichment on terrestrial plants has resulted in a substantial increase in the extent of green vegetation over the last four decades, a phenomenon known as global greening.⁸⁷ A 2024 study using data from 2001–20 (using the Leaf Area Index) found that global greening was not only present but accelerating over the period.⁸⁸ For forests in the U.S., researchers have attributed the increased density of wood volume over the last half-century to elevated carbon dioxide levels.⁸⁹

and Neglect,” *Global Ecology and Conservation*, September 2022.<https://doi.org/10.1016/j.gecco.2022.e02149>

⁸⁴ Tara J. Conkling, et al., “[Vulnerability of Avian Populations to Renewable Energy Production](#),” *Royal Society Open Science*, March 30, 2022.

⁸⁵ Jie Bao et al., “[Greenhouses for CO₂ Sequestration from Atmosphere](#),” *Carbon Resources Conversion*, August 2, 2018.

⁸⁶ NOAA Global Monitoring Laboratory, [Trends in Atmospheric Carbon Dioxide \(CO₂\)](#), accessed April 17, 2025.

⁸⁷ Karl B. Hille, “[Carbon Dioxide Fertilization Greening Earth, Study Finds](#),” NASA, April 26, 2016.

⁸⁸ Xin Chen et al., “[The Global Greening Continues Despite Increased Drought Stress Since 2000](#),” *Global Ecology and Conservation*, January 2024.

⁸⁹ Eric C. Davis, Brent Sohngen, and David J. Lewis, “[The Effect of Carbon Fertilization on Naturally Regenerated and Planted US Forests](#),” *Nature Communications*, September 19, 2022.

Higher carbon dioxide levels also affect agricultural yields. The mechanisms for how higher ambient CO₂ levels influence plant growth differ for different crops. In general, a doubling of CO₂ caused approximately a 30% increase in the reproductive yield of C3 species and <10% increase for C4 species.⁹⁰ These increases are expected to compensate for and exceed losses from projected higher temperatures in the future.

The effects of CO₂ fertilization on plant growth must also be distinguished from other factors, such as the availability of water and other nutrients. To quantify the effect of changes in CO₂ concentrations, researchers have made steady progress improving the experimental systems where CO₂ concentrations can be maintained above ambient levels and its influence on yields for specific crops determined.⁹¹ Experiments since the 1980s have shown substantial production increases for staple crops like wheat (9%–20%), rice (8%–17%), and soybeans (12%–40%) when cultivated using CO₂ concentrations of 550 ppm.⁹²

Most earlier studies have considered the effects of CO₂ fertilization at concentrations that far exceed ambient concentrations. A 2021 study published by the National Bureau of Economic Research attempted to measure the effects of smaller incremental increases in ambient CO₂ levels. The study found that “a 1 ppm increase in CO₂ equates to a 0.5%, 0.6%, and 0.8% yield increase for corn, soybeans, and wheat, respectively. Viewed retrospectively, 10%, 30%, and 40% of each crop’s yield improvements since 1940 are attributable to rising CO₂.”⁹³

Removing the contribution of CO₂ fertilization on annual yield growth since 1950 for corn and soybeans—and assuming that the same crop acreage was harvested in any year—results in fewer bushels being produced in that year. For corn, in 2024, over 6 billion fewer bushels would be produced, resulting in a loss of \$26.5 billion in crop value. For soybeans, over 2 billion bushels would be produced, which would have resulted in a loss of over \$20 billion. Similarly, one billion fewer bushels of wheat would translate to over \$600 million in lost crop value. As with other basic commodities, the lost value must be multiplied by an economic multiplier to properly measure the value lost to the U.S. economy.

III. Regulation of Mobile Emission Sources

Many impacts discussed in the previous section regarding the regulation of stationary source CO₂ emissions also apply to the regulation of CO₂ emissions from mobile sources. These include higher electricity prices and reduced electric reliability. In addition, because the materials requirements for EVs are greater than those for internal combustion engine vehicles (ICVs), the

⁹⁰ J. L. Hatfield et al., “[Climate Impacts on Agriculture: Implications for Crop Production](#),” *Agronomy Journal*, March 1, 2011.

⁹¹ Martin Erbs and Andreas Fangmeier, “[Atmospheric Carbon Dioxide Enrichment Effects on Ecosystems—Experiments and the Real World](#),” *Progress in Botany* 67 (2006).

⁹² Elizabeth A. Ainsworth and Stephen P. Long, “[30 Years of Free-Air Carbon Dioxide Enrichment \(FACE\): What Have We Learned About Future Crop Productivity and Its Potential for Adaptation?](#)” *Global Change Biology*, November 2, 2020.

⁹³ Charles A. Taylor and Wolfram Schlenker, “[Environmental Drivers of Agricultural Productivity Growth: CO₂ Fertilization of US Field Crops](#),” NBER Working Paper 29320, October 2021.

life-cycle emissions of EVs (the number of miles an EV needs to travel to offset the higher emissions involved in its manufacture) can be greater than those of ICVs. The “breakeven” emissions points also depend on the source of the electricity used to recharge EV batteries.⁹⁴

A. Summary of State and Federal Mobile Emissions Regulations

As discussed in the Introduction, the Endangerment Finding focused initially on motor vehicles. Individual states responded by enacting policies that required auto dealers to sell increasing percentages of their new vehicles to be zero-emission vehicles (ZEVs), culminating in California’s Advanced Clean Car II (ACC II) rules.⁹⁵ Eleven other states have formally adopted the ACC II rules: Oregon, Washington State, New York, Massachusetts, and Vermont have adopted ACC II, beginning in model year 2026. Colorado, New Jersey, Delaware, Rhode Island, Maryland, and New Mexico will initiate the ACC II requirement in model year 2027.⁹⁶

Under the ACC II rules, 35% of model year 2026 passenger and light truck vehicles sold in California must be zero-emission. The percentages increase steadily over time until, by the 2035 model year, 100% of all new vehicles sold in the state must be EVs. The rules apply to automakers, which will be fined if they fail to meet the sales requirements. If consumers do not wish to purchase the required percentages of EVs, the practical result will be that automakers will provide fewer of the vehicles that consumers wish to purchase. Consumers will then either keep their old vehicles or travel outside the ACC II states to purchase the vehicles they want.⁹⁷

California has also enacted Advanced Clean Truck (ACT) rules, requiring an increasing percentage of heavy-duty vehicles to be zero-emission.⁹⁸ An additional 10 states have followed suit.⁹⁹ One key problem is that the technology for heavy-duty electric trucks is in its infancy.

⁹⁴ River James, “[Carbon-Footprint Face-Off: A Full Picture of EVs vs. Gas Cars](#),” *Recurrent*, January 20, 2025; Simon Evans, “[Factcheck: 20 Misleading Myths about Electric Vehicles](#),” CarbonBrief, October 24, 2023.

⁹⁵ California Air Resources Board, [Advanced Clean Cars II](#). The rules stem from Governor Gavin Newsom’s [Executive Order N-79-20](#), issued on September 23, 2020. ZEVs include vehicles that run solely on batteries and ones that use hydrogen. Since 2012, only 18,633 hydrogen vehicles have been sold in the entire country, virtually all in California; see [Fuel Cell Electric Vehicle Sales: 2012–2025](#).

⁹⁶ On April 4, 2025, the governor of Maryland issued an executive order, “[Ensuring Success with Advanced Clean Cars II and Advanced Clean Trucks in Maryland](#),” to delay enforcement of the ACC II mandates for two years.

⁹⁷ There is a serious legal issue regarding whether states adopting the ACC II rules will be able to prohibit the registration of new vehicles purchased elsewhere by existing residents. Substantial litigation on this issue should be expected.

⁹⁸ California Air Resources Board, [Zero-Emission On-Road Medium- and Heavy-Duty Strategies](#).

⁹⁹ Anh Bui and Peter Slowik, “[U.S. State Clean Vehicle Standards](#),” *icct20*, June 4, 2024.

Current electric trucks have much less range than diesel-fueled ones and require significant charging times. They are also far more costly than diesel trucks.¹⁰⁰

In addition to mandates for ZEV sales, 19 states, including California, have adopted a Low Carbon Fuel Standard (LCFS). Because the carbon content of fossil fuels like gasoline and diesel are fixed by their chemical makeup, the LCFS requires increased reliance on alternative fuels, such as ethanol and biodiesel, by reducing allowable emissions per unit of energy from fossil fuels.¹⁰¹

In April 2024, the EPA published its Final Rule adopting new emissions standards for light-duty vehicles, beginning with the 2027 model year.¹⁰² The EPA rule requires that, by the 2032 model year, CO₂ emissions from new cars and light trucks cannot be more than 73 grams/mile and 90 grams/mile, respectively, roughly 50% lower than allowable emissions for the 2027 model year. The EPA rule also requires medium-duty vehicles to reduce CO₂ emissions by about 40% below allowable levels for the 2027 model year. Subsequently, in June 2024, the National Highway Traffic Safety Administration (NHTSA) adopted new mileage standards for ICVs, which are designed to reduce the allowable CO₂ emissions per mile.¹⁰³

B. Additional Infrastructure Costs

Infrastructure for EVs will require vast quantities of minerals and equipment to install the required upgrades to local distribution systems, transmission lines, and substations. The cost of these additions has been estimated to be between \$2 trillion and \$4 trillion, before accounting for the higher prices that will be caused by increased demand.¹⁰⁴

To enable an EV future that provides the same freedom of movement that individuals and businesses enjoy today will require massive upgrades to the entire electrical delivery system. Home chargers (“Level 2” chargers) will require dedicated electric circuits, much as electric stoves and electric clothes dryers have. The main circuit boxes in millions of older homes to which electricity is delivered will need to be upgraded to handle the increased home electric loads.

To accommodate the increased electricity needed for EV charging (and other electrification policies that states are adopting), electric utilities will have to upgrade their local distribution systems—the poles and wires running down streets—with millions of larger transformers, thousands (if not millions) of miles of larger wires, and even bigger utility poles to handle the additional weight.

¹⁰⁰ Shreya Agrawal, “[Fact Sheet: The Future of the Trucking Industry: Electric Semi-Trucks](#),” Environmental and Energy Study Institute, May 11, 2023.

¹⁰¹ California Air Resources Board, [LCFS Basics](#).

¹⁰² EPA, “[Final Rule: Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles](#),” April 18, 2024.

¹⁰³ National Highway Traffic Safety Administration (NHTSA), [Corporate Average Fuel Economy Final Rule](#), June 7, 2024.

¹⁰⁴ Lesser, *supra* note 11.

Furthermore, infrastructure is needed to replace our country’s almost 200,000 retail gasoline stations and more than 1 million gas-pump nozzles. Providing drivers with a similar level of convenience means installing high-voltage “Level 3” chargers to provide relatively quick recharging, which will require installing much larger circuits and transformers.

A network of charging stations along the 220,000 miles of interstate and U.S. highways will also be needed. Consider that a single on-road charging station will have the electric power demand of a small town. High-voltage transmission lines must be constructed and extended to those charging stations, in addition to huge transformers and new substations that will be needed to handle the higher electric loads. Yet utilities today must wait as long as five years for delivery of such transformers. Moreover, delivering the additional electricity required for an all-EV world means building several hundred thousand additional miles of new transmission lines or re-conductoring (i.e., rewiring with higher capacity wire).

If EVs are the “future” of transportation, the infrastructure required will be developed over time by the private sector, just as the infrastructure for ICVs was developed. By forcing EV adoption, however, the government diverts resources away from more productive enterprises. As discussed earlier in this report, this diversion of resources represents a type of crowding out of private investment.

C. The Cost of Increased Dependence on Foreign-Sourced Raw Materials and Equipment

A key strategic issue of EV mandates—whether direct like the ACC II and ACT rules, or indirect in the form of mandatory decreases in allowable CO₂ emissions per mile—is the need for materials, including copper, manganese, nickel, cobalt, and rare earth minerals. Owing to environmental restrictions placed on U.S. mining, much of these materials are imported from overseas—notably, China.¹⁰⁵

For example, the typical EV requires two to three times the quantity used in ICVs—120–80 pounds of copper per EV, versus 50 pounds for ICVs, and six times more minerals overall.¹⁰⁶ It has been estimated that full electrification supplied by wind, solar, and batteries will require 10 times more rare earth minerals than are currently used.¹⁰⁷

As the recent trade war has highlighted, the U.S. is highly dependent on China for most rare earth minerals, which China has restricted.¹⁰⁸ Although “rare earths” in reality aren’t especially rare, according to a recent report by the International Energy Agency (IEA), China has a 50%–

¹⁰⁵ Mark P. Mills, “[Mines, Minerals, and ‘Green’ Energy: A Reality Check](#),” Manhattan Institute, July 9, 2020; idem, “[The Hard Math of Minerals](#),” *Issues in Science and Technology*, January 27, 2022; see also S&P Global, “[The Future of Copper: Will the Looming Supply Gap Short-Circuit the Energy Transition?](#)” July 2022.

¹⁰⁶ The amount of copper used depends on the type and size of battery and the size of the motor. See IEA, “[The Role of Critical Minerals in Clean Energy Transitions](#),” March 2022.

¹⁰⁷ Mills, *supra* note 104; see also Lukas Boer, Andrea Pescatori, and Martin Stuermer, “[Energy Transition Metals](#),” International Monetary Fund, Working Paper WP/21/243, October 2021.

¹⁰⁸ Gracelin Baskaran and Meredith Schwartz, “[The Consequences of China’s New Rare Earths Export Restrictions](#),” Center for Strategic & International Studies, April 14, 2025.

90% market share for many of these minerals.¹⁰⁹ That dependence renders the U.S. more strategically vulnerable, and allows China to exercise market power and raise costs.

In addition to their use in wind turbines and solar panels, these minerals are used to manufacture EVs. They are also important to numerous defense technologies (e.g., aircraft, ships, radar installations). EV mandates artificially increase the demand for rare earths. Not only is this increasing the price of these minerals, but it is also increasing the U.S. dependence on a foreign adversary.

IV. Conclusions

Sound policy analysis requires evaluating benefits *and* costs. While the worldwide benefits of federal and state policies to reduce GHG emissions are touted using estimates of the social cost of carbon, the full costs of these same policies have never been fully addressed. Instead, policymakers have engaged in what is best described as Pollyannish claims of new industries and jobs to be created, greater environmental “justice” (never explicitly defined or measured), and ever-lower energy costs.

As this report has discussed, the economic realities are far different. Energy and environmental policies justified by the Endangerment Finding have significant economic and social costs. While forcing increased electrification and, hence, dependence on reliable and affordable electricity, these policies are reducing the reliability and stability of the electric grid and increasing the cost of electricity that consumers and businesses must rely on. The recent blackout in the Iberian Peninsula, which was caused by a sudden change in grid frequency because of a lack of generators providing needed system inertia, is an example of what may lie ahead.

If fully implemented, the costs of the various state and federal energy policies are likely to be trillions of dollars. These policies are increasing fossil fuel energy costs, causing additional inflation while reducing economic growth. They are also crowding out more productive private investment.

Moreover, the raw materials requirements—such as rare earths, copper, and specialized electrical steel—are staggering. In the immediate term, they have made the U.S. heavily dependent on China. In the long term, it is not clear whether the raw materials needed for the envisioned policies even exist.¹¹⁰

Policies to reduce GHGs come with their own environmental impacts, including the loss of species. These impacts have been denied or, more often, ignored. This has been especially true for offshore wind facilities. Owing to their low power densities, the land requirements of wind and solar generation are huge.¹¹¹ Consequently, they are located in rural areas, imposing costs on

¹⁰⁹ IEA, *Global Critical Minerals Outlook 2024*, May 2024.

¹¹⁰ Simon P. Michaux, “[Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels](#),” Geological Survey of Finland/Geologian tutkimuskeskus, August 18, 2022.

¹¹¹ Wallace Manheimer, “[Civilization Needs Sustainable Energy – Fusion Breeding May Be Best](#),” *Journal of Sustainable Development* 15 (2), 98–131, February 9, 2022; Lars Schernikau, William Hayden Smith, Rosemary Falcon, “[Full Cost of Electricity ‘FCOE’ and Energy Returns ‘eROI’](#),” *Journal of Management and Sustainability* 12 (1), 96–121, May 23, 2022.

local residents in the form of adverse health impacts and lower property values. It often removes valuable lands from agricultural production. Moreover, siting these resources far from load centers requires constructing thousands of miles of high-voltage transmission lines to deliver the electricity that they produce to urban load centers.

Identifying and estimating the true costs of these policies does not mean that climate change is not real (although there is no evidence of a climate “crisis”).¹¹² Instead, it means that a full accounting of the benefits and costs of these (and other) policies is required. This has not been the case with the policies driven by the Endangerment Finding.

¹¹² William Happer, Richard Lindzen, Gregory Wrightstone, “[Challenging ‘Net Zero’ with Science](#),” CO₂ Coalition, Fairfax, VA, USA, February 23, 2023; Gregory Wrightstone, [A Very Convenient Warming: How Modest Warming and More CO₂ are Benefiting Humanity](#), Silver Crown Productions, LLC, October 2023.