Rebutting 33 False Claims About Solar, Wind, and Electric Vehicles

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INTRODUCTION

Getting the U.S. energy system onto an environmentally sustainable track will require rapid and widespread development of wind, solar, and other renewable energy facilities; corresponding storage, transmission, and distribution infrastructure; and timely industry-specific transitions, such as battery electric vehicles replacing their combustion-engine counterparts. Broad public support exists for transformative climate policies, with a June 2023 Pew Research Center survey finding that 67% of U.S. adults prioritize developing renewable energy sources over increased fossil fuel production. However, “misinformation” and coordinated “disinformation” have at times undermined support for renewable energy projects and electric vehicles. This report addresses some of the more prevalent and persistent distortions about solar energy, wind energy, and electric vehicles, with the aim of promoting a more informed discussion.

While the impact of misinformation and disinformation can be difficult to measure, alarming data has begun to emerge. A Monmouth University poll found, for instance, that support in New Jersey for offshore wind farms had declined from 76% in 2019, to 54% by August 2023. This shift is likely due, in large part, to dubious claims, some of them coming from fossil-fuel funded opposition groups, which have attempted to blame wind farm surveys for recent spikes in whale deaths off the United States’ northeastern coast. More generally, both nationwide and in communities on the front lines of our energy transition, anecdotal doubts and coordinated disinformation efforts have dampened public enthusiasm for ambitious renewables infrastructure, particularly among concentrated segments of our polarized population. For example, support for offshore wind among New Jersey Republicans dropped from 69% to 28% from 2019 to August 2023, while support among New Jersey Democrats only dropped from 79% to 76.

False claims about renewable energy come in many varieties. Some claims rely on sheer bombast, seemingly designed to shock and inflame audiences, rather than contribute to informed debate on pressing policy choices (“Solar farms depend entirely on subsidies from your hard earned money. When the subsidies are gone, the solar farms are abandoned!”). Some emphasize theoretical impacts of poorly-designed...
This report does not examine the origins of the false claims or the motivations of those who disseminate them. However, it is well documented that much of it comes from deliberately misleading sources, such as astroturf “local” organizations funded by distant policy advocates, themselves funded by fossil-fuel producers. Other researchers, including Brown University’s Climate and Development Lab, have extensively mapped out some of these connections in the context of opposition to offshore wind development.

Ultimately, an honest reckoning with what will be required to address the climate crisis requires a fact-based evaluation of the best available pathways to avoid the worst-case scenarios. Renewable energy and its offshoots can significantly reduce climate threats, improve public health, and provide jobs for millions of Americans. The authors designed this report so that, despite the longevity of long-since-debunked misinformation, members of the public, and particularly residents of communities contemplating utility-scale renewable energy projects, can cultivate balanced and informed opinions.

With that context, this report identifies and examines 33 of the most pervasive misconceptions about solar energy, wind energy, and electric vehicles. The false claims about each of these technologies are presented roughly in the following order: misconceptions pertaining to human health, then misconceptions pertaining to environmental impacts, then misconceptions pertaining to economic impacts, and then other

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10 Welcome to No Solar in Logan County (Ohio), NO SOLAR IN LOGAN COUNTY (Ohio), https://perma.cc/P45M-W5NF (last visited March 25, 2024).
12 NO TO SOLAR, supra note 7.
15 ISAAC LEVIN ET AL., CLIMATE AND DEVELOPMENT LAB, AGAINST THE WIND: A MAP OF THE ANTI-OFFSHORE WIND NETWORK IN THE EASTERN UNITED STATES (2023), https://drive.google.com/file/d/1a64hVMLqR6p_a392O-g9LSERk7GBb0/view.
misconceptions that do not fit into any of these categories. To identify the most common misconceptions regarding renewables and electric vehicles, the authors first conducted primary research that included reviewing social-media groups and websites created to oppose renewable energy projects or policies, as well as existing press coverage about misinformation. The authors then developed transparent, fact-based responses to these misconceptions, relying to the greatest extent possible on academic literature and government publications. The authors would like to thank Eric Larson, Charles Kutscher, Aniruddh Mohan, and David Gahl for reviewing these responses for technical accuracy. The authors would also like to thank Achyuth Anil and Miguel Severino for their assistance in preparing the report. Any errors that remain are the authors’ own. Because each of these responses is designed to stand on its own, there is some repetition in content from one response to the next.

Importantly, this is not the first publication to attempt to debunk or contextualize dubious claims about clean energy. Below is a short, non-comprehensive list of other efforts to clarify misinformation and disinformation pertaining to renewable energy and electric vehicles:

- The United States Environmental Protection Agency’s breakdown of “electric vehicle myths.”
- RMI’s Reality Check: The IEA Busts 10 Myths about the Energy Transition.
- USA Today’s Do wind turbines kill birds? Are solar panels toxic? The truth behind green-energy debates.
- Carbon Brief’s factchecks on electric vehicles and renewable energy, including: Factcheck: How electric vehicles help to tackle climate change; Factcheck: 21 misleading myths about electric vehicles; and Factcheck: Is solar power a ‘threat’ to UK farmland?
- The Center for American Progress’s The Truth About Offshore Wind: Busting Oil Money Myths and Misinformation.

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16 The dividing line among these categories is often blurry: for example, climate change has impacts on human health, the non-human environment, and the economy.
• The Annenberg Public Policy Center’s website FactCheck.org, which includes factchecks on climate change related topics, including electric vehicles.

• The Brown Climate and Development Lab’s Discourses of Climate Delay in the Campaign Against Offshore Wind: A Case Study from Rhode Island.

• Emily Atkin’s A guide to electric car misinformation.

This publication aims to build on these other reports and should be read in conjunction with them.

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PART A: FALSE CLAIMS ABOUT SOLAR ENERGY (#1–#14)
1. PART A: FALSE CLAIMS ABOUT SOLAR ENERGY (#1-#14)

False Claim #1: Electromagnetic fields from solar farms are harmful to human health.

“The EMF (electromagnetic field) from solar farms poses serious health risks especially to those who have electromagnetic hypersensitivity.”

The electromagnetic fields generated at a solar farm are similar in strength and frequency to those of toaster ovens and other household appliances—and harmless to humans. A detailed analysis from North Carolina State University concluded that there is “no conclusive and consistent evidence” of “negative health impact[s] from the EMF [electromagnetic fields] produced in a solar farm.”

EMF exposure levels vary according to the EMF source, proximity to the source, and duration of the exposure. On a solar farm, EMFs are highest around electrical equipment such as inverters. However, even when standing next to the very largest inverter at a utility-scale solar farm, one’s exposure level (up to 1,050 milligauss, or mG) is less than one’s exposure level while operating an electric can opener (up to 1,500 mG), and well within accepted exposure limits (up to 2,000 mG). When standing just nine feet from a residential inverter, or 150 feet from a utility-scale inverter, one’s exposure drops to “very low levels of 0.5 mG or less, and in many cases . . . less than background levels (0.2 mG).” For comparison, a typical American’s average background exposure level is 1mG, reaching 6 mG when standing three feet from a refrigerator, and 50 mG when standing three feet from a microwave.

The electromagnetic fields present on a solar farm constitute “non-ionizing radiation,” which, by definition, generates “enough energy to move atoms in a molecule around (experienced as heat), but not enough energy to remove electrons from an atom or molecule (ionize) or to damage DNA.” In addition, EMFs are extremely low in frequency, which means they contain “less energy than other commonly encountered types of non-ionizing radiation like radio waves, infrared radiation, and visible light.”

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29 NO TO SOLAR, supra note 7.
31 Id. at 15.
33 Tommy Cleveland, supra note 30 at 15.
35 Tommy Cleveland, supra note 30, at 16.
36 Id. at 15.
False Claim #2: Toxic heavy metals, such as lead and cadmium, leach out from solar panels and pose a threat to human health.

"Studies have shown the heavy metals in solar panels namely lead and cadmium, can leach out of the cells and get into groundwater, as well as affect plants."\(^{37}\)

Roughly 40% of new solar panels in the United States and 5% of new solar panels in the world contain cadmium,\(^{38}\) but this cadmium is in the form of cadmium telluride, which is non-volatile, non-soluble in water, and has 1/100\(^{th}\) the toxicity of free cadmium.\(^{39}\) Most solar panels, like many electronics, contain small amounts of lead.\(^{40}\) However, the Massachusetts Department of Energy Resources (DER) has assessed that “because PV panel materials are enclosed, and don’t mix with water or vaporize into the air, there is little, if any, risk of chemical releases to the environment during normal use.”\(^{41}\) The Massachusetts DER has further assessed that, even in the unlikely event of panel breakage, releases of chemicals used in solar panels are "not a concern."\(^{42}\)

All materials in a solar panel are “insoluble and non-volatile at ambient conditions,” and “don’t mix with water or vaporize into air.”\(^{43}\) Moreover, they are encased in tempered glass that not only withstands high temperatures, but is also strong enough to pass hail tests and is regularly installed in Arctic and Antarctic conditions.\(^{44}\) It is theoretically possible that, when exposed to extremely high heat exceeding that of a typical residential fire, panels “could emit vapors and particulates from PV panel components to the air.” But that risk is limited by the fact that “the silicon and other chemicals that comprise the solar panel would likely bind to the glass that covers the PV cells and be retained there.”\(^{45}\) When a cadmium telluride panel is exposed to fire of an intensity sufficient to melt the glass on the panel, "over 99.9% of the cadmium [is encapsulated in] the molten glass."\(^{46}\) Furthermore, a 2013 analysis found that, even in the worst-case scenarios of earthquakes, fires, and floods, "it is unlikely that the [cadmium] concentrations in air and sea water will exceed the environmental regulation values."\(^{47}\)


\(^{41}\) Massachusetts Department of Energy Resources et al., supra note 32 at 5.

\(^{42}\) Id.

\(^{43}\) Id.

\(^{44}\) Id.

\(^{45}\) Id.

\(^{46}\) NClean Energy Technology Center, supra note 39 at 7.

One peer-reviewed study in the *Journal of Natural Resources and Development* found it unlikely for lead or cadmium to leach into the soil from functional solar panels. Measuring heavy metal concentrations in the soil at various distances, researchers found no significant differences in lead or cadmium concentrations directly underneath solar panels, compared to soil 45 or 100 feet away. The study further found that “lead and cadmium were not elevated in soils near PV systems and were far below levels considered to be an imminent or future danger to environmental health.”

Although the study did find higher levels of selenium in soil directly underneath solar panels, the study noted that the presence of selenium was possibly a “result of the cement used in construction,” rather than leaching from the panels themselves. In addition, the study noted that even the highest selenium concentrations observed were below the EPA’s risk threshold for mammals. Finally, the study noted that fly ash, a product of coal combustion “commonly disposed of in landfills and as a soil amendment in agriculture,” contains significantly higher concentrations of lead (40x), cadmium (1.1x) and selenium (4x) than the soil samples taken directly underneath the solar panels in the study area.

**False Claim #3: Solar panels generate too much waste and will overwhelm our landfills.**

“Solar panels pose a huge risk for overfilling the landfills.”

The amount of waste that solar panels are expected to generate over the next few decades is trivial compared to the amount of waste that will be generated by fossil fuels. A study published in Nature Physics in October 2023 found that “35 years of cumulative PV module waste (2016-2050) is dwarfed by the waste generated by fossil fuel energy and other common waste streams.” Specifically, the study found that “if we do not decarbonize and transition to renewable energy sources, coal ash and oily sludge waste generated by fossil fuel energy would be 300-800 times and 2-5 times larger [in mass], respectively, than PV module waste.”

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48 Seth A. Robinson et al., *Potential for leaching of heavy metals and metalloids from crystalline silicon photovoltaic systems*, 9 J. NAT. RES. AND DEV. 19, 21 (2019), [https://doi.org/10.5027/jnrd.v9i0.02](https://doi.org/10.5027/jnrd.v9i0.02).
49 Id. at 21-22.
51 Robinson et al., *supra* note 48, at 21-22.
52 Id.
53 Id.
54 NO TO SOLAR, *supra* note 7.
55 Heather Mirletz et al., *Unfounded concerns about photovoltaic module toxicity and waste are slowing decarbonization*, NATURE PHYSICS, October 2023, [https://www.nature.com/articles/s41567-023-02230-0](https://www.nature.com/articles/s41567-023-02230-0).
In addition, although only about 10% to 15% of solar panels are recycled in the United States, the U.S. Department of Energy has awarded funding under the Infrastructure Investment and Jobs Act for additional research and development for solar technology recycling. A 2024 study on solar PV recycling concluded that “PV recycling will reduce waste, and CO2 emissions, while contributing to a sustainable environment,” and that “[i]t is expected that the research for efficient PV recycling strategies will accelerate as the PV industry grows and as many more organizations and government work towards a sustainable future.”

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56 Id.
Already, some companies have been able to recover 90% of solar panels’ mass in their recycling processes. Bulk materials such as glass, steel, and aluminum are recoverable through existing recycling lines, while certain semiconductor materials (tellurium and cadmium) can also be recovered at very high rates of 95% to 97%. Valuable materials in the panels, including silver, copper, and crystalline silicon, are actively sought for the development of other products, including the next generation of solar panels. In addition, new companies are emerging with innovative technologies to recycle solar panels.

False Claim #4: Clearing trees for solar panels negates any climate change benefits.

“It isn’t ‘green’ to cut down thousands of acres of trees to build large solar plants. Trees remove carbon from the atmosphere and slow global warming. Deforestation contributes to climate change.”

Forests have immense ecological benefits, recreational benefits, and intrinsic value. However, when looking at the narrow but important issue of carbon accounting, it is usually not true that removing trees to build a solar farm negates any emissions reductions from solar generation. In fact, an acre of solar panels in the United States usually offsets significantly more carbon dioxide emissions than an acre of planted trees can sequester.

In the United States, the emissions intensity of electricity produced by natural gas-fired power plants is roughly 1,071 pounds of carbon dioxide per megawatt-hour (MWh). The emissions intensity of solar PV, meanwhile, is about 95 pounds per MWh, a difference of 976 pounds per MWh compared to natural gas. According to a 2022 Journal of Photovoltaics study, utility-scale solar power produces between 394 and 447 MWh per acre per year. When displacing electricity from natural gas, an acre of solar panels, producing zero-emissions electricity would therefore save between 385,000 to 436,000 pounds, or 175 to 198 metric tons, of carbon dioxide per year.

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64 Id.
67 Id.
By comparison, according to the EPA, an average acre of U.S. forest sequesters 0.857 metric tons of carbon dioxide per year.\textsuperscript{69} Thus, an average acre of solar panels in the United States reduced approximately 204–231 times more carbon dioxide per year than an acre of forest.

Furthermore, while removing trees from forests releases stored carbon, such emissions can be offset by solar energy generation and the resulting reduction in fossil fuel-driven emissions. The EPA has estimated the average acre of forests contains 83 metric tons of carbon, and approximately half of that amount is sequestered in soil.\textsuperscript{70} Even assuming that all 83 metric tons of carbon (comprising 304 metric tons of carbon dioxide)\textsuperscript{71} were released when building a solar farm on an acre of forested land, those emissions could be offset within two years of operation of a typical solar farm.\textsuperscript{72} Finally, to put the threat to forests in context, only about 4% of solar projects in the United States are being sited on currently-forested lands.\textsuperscript{73}

**False Claim #5: Solar energy is worse for the climate than burning fossil fuels.**

"It is likely that solar farms are making climate change worse."\textsuperscript{74}

There is overwhelming evidence that the lifecycle emissions\textsuperscript{75} of solar energy are far lower than those of all fossil fuel sources, including natural gas.\textsuperscript{76} On average, it takes only three years after installation for a solar panel to offset emissions from its production and transportation.\textsuperscript{77} Modern solar panels have a functional lifecycle of 30–35 years, allowing more than enough time to achieve carbon neutrality and generate new emissions-free energy.\textsuperscript{78}

A National Renewable Energy Laboratory (NREL) report released in 2021 examined “approximately 3,000 published life cycle assessment studies on utility-scale electricity generation from wind, solar photovoltaics, concentrating solar power, biopower, geothermal, ocean energy, hydropower, nuclear, natural gas, and coal technologies, as well as lithium-ion


\textsuperscript{71} EPA’s Greenhouse Gases Equivalencies Calculator explains that, to convert carbon density to carbon dioxide density, metric tons of carbon should be multiplied by the ratio of the molecular weight of carbon dioxide to that of carbon (44/12). \textsuperscript{Id.}

\textsuperscript{72} This calculation is based on the fact that an acre of solar panels displacing electricity from natural gas would save between 175 to 198 metric tons of carbon dioxide per year, as described earlier in this entry.

\textsuperscript{73} L. Kruitwagen et al., A Global Inventory of Photovoltaic Solar Energy Generating Units, 598 Nature 604 (October 2021) (Supplemental Data for Supplemental Figure 10), https://doi.org/10.1038/s41586-021-03957-7. Supplemental data for Supplemental Figure 10 establishes that, as of December 2018, solar capacity across all land types in the U.S. was 54.14 GW, while solar capacity across land labelled as “tree covered” was 2.15 GW. \textsuperscript{Id}. This represents roughly 4% of the total capacity.

\textsuperscript{74} No To Solar, supra note 7.

\textsuperscript{75} Lifecycle emissions for energy technologies encompass emissions associated with the operation of an energy facility, such as combustion of fossil fuels. Lifecycle emissions also encompass upstream emissions associated with resource extraction, manufacturing, and construction of a facility, along with downstream emissions associated with decommissioning of a facility. Nat’l Renewable Energy Laboratory, supra note 66, at 1.


\textsuperscript{77} See Cool Effect, supra note 76.

battery, pumped storage hydropower, and hydrogen storage technologies. The report found widespread agreement that all modes of solar power have total lifecycle emissions significantly below those of all fossil fuels. The report found specifically that the total lifecycle emissions for solar photovoltaic (PV) and concentrating solar power (CSP) panels were 43 and 28 grams of CO$_2$-eq/KWh (carbon dioxide-equivalents per kilowatt-hour), respectively. Coal, by contrast, generated lifecycle emissions of 1,001 grams of CO$_2$-eq/KWh, and natural gas generated lifecycle emissions of 486 grams of CO$_2$-eq/KWh.

<table>
<thead>
<tr>
<th>Table 1. Median Published Life Cycle Emissions Factors for Electricity Generation Technologies, by Life Cycle Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generation Technology</strong></td>
</tr>
<tr>
<td>---------------------------</td>
</tr>
<tr>
<td>Biomass</td>
</tr>
<tr>
<td>Concentrating Solar Power$^b$</td>
</tr>
<tr>
<td>Geothermal</td>
</tr>
<tr>
<td>Hydropower</td>
</tr>
<tr>
<td>Ocean</td>
</tr>
<tr>
<td>Wind$^c$</td>
</tr>
<tr>
<td>Pumped-storage hydropower</td>
</tr>
<tr>
<td>Lithium-ion battery</td>
</tr>
<tr>
<td>Hydrogen fuel cell</td>
</tr>
<tr>
<td>Nuclear$^d$</td>
</tr>
<tr>
<td>Natural gas</td>
</tr>
<tr>
<td>Oil</td>
</tr>
<tr>
<td>Coal</td>
</tr>
</tbody>
</table>

Figure 2: Total lifecycle emissions for different energy sources. 

Source: NREL.

To be fair, there are some outlier studies. For example, one study examined a worst-case scenario in which the coal-powered manufacture of inefficiently sized solar PV cells may contribute to greater lifecycle emissions than the cleanest and

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$^a$ See Nat’l Renewable Energy Laboratory, supra note 66, at 1.
$^b$ Id. at 1-3.
$^c$ See Schömer, supra note 76, at 1335.
$^d$ Id.
most efficient fossil fuel plants. However, the conclusion that solar is worse for the climate than fossil fuels is not backed up by NREL’s more extensive survey.

In addition to having smaller greenhouse gas emissions, solar power likewise outperforms fossil fuels in minimizing direct heat emissions. A 2019 Stanford publication notes that, for solar PV and CSP, net heat emissions are in fact negative, because these technologies “reduce sunlight to the surface by converting it to electricity,” ultimately cooling “the ground or a building below the PV panels.” The study found that rooftop and utility-scale solar PV have heat emissions equivalent to negative 2.2 g-CO2e/kWh-electricity, compared to the positive heat emissions associated with natural gas, nuclear, coal, and biomass.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Anthropogenic heat emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar rooftop</td>
<td>-2.2</td>
</tr>
<tr>
<td>Solar utility</td>
<td>-2.2</td>
</tr>
<tr>
<td>CSP</td>
<td>-2.2</td>
</tr>
<tr>
<td>Wind onshore</td>
<td>-1.7 to -0.7</td>
</tr>
<tr>
<td>Wind offshore</td>
<td>-1.7 to -0.7</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>0</td>
</tr>
<tr>
<td>Wave</td>
<td>0</td>
</tr>
<tr>
<td>Tidal</td>
<td>0</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1.6</td>
</tr>
<tr>
<td>Biomass</td>
<td>3.4</td>
</tr>
<tr>
<td>Natural gas-CCS/U</td>
<td>0.61</td>
</tr>
<tr>
<td>Coal-CCS/U</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Figure 3: The 100-year CO2e emissions impact associated with different energy sources’ heat emissions, measured in g-CO2e/kWh-electricity.

Source: M.Z. Jacobson

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86 Id. Reproduced and adapted with permission.
Looking at academic scholarship from outside of the United States, a 2022 University of Western Ontario study tracking the effect of anthropogenic heat emissions on global warming noted that solar technologies emit an "insignificant amount of heat." Likewise, a 2022 analysis from India’s Hirwal Education Trust’s College of Computer Science and Information Technology describes the global impact of solar panel heat emissions as "relatively small."

**False Claim #6: Solar projects harm biodiversity.**

"Construction of an industrial-scale solar powerplant . . . creates an ecological wasteland."

When properly developed, including by incorporating pollinator habitat in project design, large-scale solar farms can sustain and even increase natural biodiversity. Microclimates within solar farms can enhance botanical diversity, which, in turn can enhance the diversity of the site’s invertebrate and bird populations. In addition, the shade under solar panels can offer critical habitat for a wide range of species, including endangered species. Shady patches likewise prevent soil moisture loss, boosting plant growth and diversity, particularly in areas impacted by climate extremes.

Proactive measures taken before and after a solar farm’s construction can further enhance biodiversity. Prior to installation, developers can mitigate adverse impacts by examining native species’ feeding, mating and migratory patterns and ensuring that solar projects are not sited in sensitive locations or constructed at sensitive times. For example, developers can schedule construction to coincide with indigenous reptiles’ and amphibians’ hibernation periods, while avoiding breeding periods.

Additionally, developers can invest in habitat restoration once solar projects have been installed, such as by replanting indigenous flowering species that provide nectar to insects, which also benefits mammals and ground nesting birds. A recent study on the impact of newly-established insect habitat on solar farms in agricultural landscapes found increases in

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89 CITIZENS FOR RESPONSIBLE SOLAR, supra note 9.


91 Id.


93 Greg Barron-Bafford et al., *Agrivoltaics provide mutual benefits across the food-energy-water nexus in the drylands*, 2 NATURE SUSTAINABILITY 848, 851 (2019), [https://doi.org/10.1038/s41893-019-0364-5](https://doi.org/10.1038/s41893-019-0364-5).


95 Id. at 51.

96 Id. at 54, 82.
floral abundance, flowering plant species richness, insect group diversity, native bee abundance, and total insect abundance.\textsuperscript{97}

Pollinators play a crucial role in U.S. farming, with more than one third of crop production reliant on pollinators.\textsuperscript{98} Bee populations alone contribute an estimated $20 billion annually to U.S. agriculture production and up to $217 billion worldwide.\textsuperscript{99} Recognizing these important contributions, the U.S. Department of Energy’s Solar Technologies Office is currently funding or tracking numerous studies that seek to maximize solar farms’ positive impacts on pollinator-friendly plants.\textsuperscript{100}

**False Claim #7: Solar projects will reduce agricultural production, hurting farmers and rural communities.**

"Ask yourself, if several thousand acres of agricultural land is converted to industrial solar facilities, who will grow your food? Bill Gates? Mark Zuckerberg?"\textsuperscript{101}

Ambitious solar deployment would utilize a relatively small percentage of U.S. land when compared to the land currently being used for agriculture. The Department of Energy estimated that total U.S. solar development would take up roughly 10.3 million acres in a scenario in which cumulative solar deployment reaches 1,050–1,570 GW by 2050, the highest land-use scenario that DOE assessed in its 2021 *Solar Futures Study*.\textsuperscript{102} If all 10.3 million acres of solar farms were sited on farmland, they would occupy only 1.15% of the 895,300,000 acres of U.S. farmland as of 2021.\textsuperscript{103} However, many of these projects will not be located on farmland.\textsuperscript{104}

Furthermore, solar arrays can be designed to allow, and even enhance, continued agricultural production on site. This practice, known as agrivoltaics, provides numerous benefits to farmers and rural communities, especially in hot or dry climates.\textsuperscript{105} Agrivoltaics allow farmers to grow crops and even to graze livestock such as sheep beneath or between rows

\textsuperscript{97} Leroy J. Walston et al., *If you build it, will they come? Insect community responses to habitat establishment at solar energy facilities in Minnesota, USA*, 19 ENV'TL RESEARCH LETTERS 14053 (2024), at 1, https://iopscience.iop.org/article/10.1088/1748-9326/ad0f72.


\textsuperscript{99} Id.


\textsuperscript{101}No Solar in Logan County (Ohio), *supra* note 10.


of solar panels.\textsuperscript{106} When mounted above crops and vegetation, solar panels can provide beneficial shade during the day.\textsuperscript{107} Multiple studies have shown that these conditions can enhance a farm’s productivity and efficiency.\textsuperscript{108} One study found, for example, that “lettuces can maintain relatively high yields under PV” because of their capacity to calibrate “leaf area to light availability.”\textsuperscript{109} Extra shading from solar panels also reduces evaporation, thereby reducing water usage for crops by around 14-29\%, depending on the level of shade.\textsuperscript{110} Reduced evaporation from solar installations can likewise mitigate soil erosion.\textsuperscript{111} Solar farms can also create refuge habitats for endangered pollinator species, further boosting crop yields while supporting native wild species.\textsuperscript{112} Overall, agrivoltaics can increase the economic value of the average farm by over 30\%, while increasing annual income by about 8\%.\textsuperscript{113} Farmers in other countries have begun implementing agrivoltaic systems.\textsuperscript{114} As of March 2019, Japan had 1,992 agrivoltaic farms, growing over 120 different crops while simultaneously generating 500,000 to 600,000 MWh of energy.\textsuperscript{115}

Furthermore, the argument that solar development will imperil the food supply is belied by the fact that tens of millions of acres of farmland are currently being used to grow crops for other purposes, such as the production of corn ethanol. Currently, roughly 90 million acres of agricultural land in the United States is dedicated to corn, with nearly 45\% of that corn being used for ethanol production.\textsuperscript{116} Solar energy could provide a significantly more efficient use of the same land. Corn-derived ethanol used to power internal combustion engines has been calculated to require between 63 and 197 times more land than solar PV to achieve the same number of transportation miles.\textsuperscript{117} If converted to electricity to power electric vehicles, ethanol would still need roughly 32 times more land than solar PV to achieve the same number of transportation miles.\textsuperscript{118} And even when accounting for other energy by-products of ethanol production, solar PV produces between 14 and 17 times more gross energy per acre than corn.\textsuperscript{119} The figure below contrasts the land use

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\textsuperscript{107} Henry J. Williams et. al., The potential for agrivoltaics to enhance solar farm cooling, Applied Energy 332 (2023), https://doi.org/10.1016/j.apenergy.2022.120478.


\textsuperscript{109} Hélène Marrou et. al., Productivity and Radiation use Efficiency of Lettuces Grown in the Partial Shade of Photovoltaic Panels, 44 EUR. J. AGRONOMY 54, 60, 63 (2013), https://doi.org/10.1016/j.eja.2012.08.003.


\textsuperscript{111} Id.

\textsuperscript{112} Empowering Biodiversity on Solar Farms, University of Georgia College of Agricultural and Environmental Sciences, 2020, https://www.caes.uga.edu/research/impact/impact-statement/9839/empowering-biodiversity-on-solar-farms.html.

\textsuperscript{113} Dinesh & Pearce, supra note 110, at 305.


\textsuperscript{115} Id. at 2. This is enough energy to power roughly 50,000 American households. U.S. Energy Information Admin., Use of energy explained: Energy use in homes, https://www.eia.gov/energyexplained/use-of-energy/electricity-use-in-homes.php (last visited March 25, 2024).


\textsuperscript{118} Id.

\textsuperscript{119} Id.
requirements of solar PV with dedicated biomass and other energy sources. Whereas dedicated biomass consumes an average of 160,000 hectares of land per terawatt-hour per year, ground-mounted solar PV consumes an average of 2,100.\textsuperscript{120}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Average land-use intensity of electricity, measured in hectares per terawatt-hour per year. \textbf{Source: U.S. Global Change Research Program (visualizing data from Jessica Lovering et al.).}\textsuperscript{121}}
\end{figure}

Finally, while solar installations, like any infrastructure projects, will inevitably have some adverse impacts, the failure to build the infrastructure necessary to avoid climate change poses a far more severe threat to agricultural production. Climate change already harms food production across the country and globe through extreme weather events, weather instability, and water scarcity.\textsuperscript{122} The most recent Intergovernmental Panel on Climate Change (IPCC) report forecasts that climate change will cause up to 80 million additional people to be at risk of hunger by 2050.\textsuperscript{123} A 2019 IPCC report forecasted up

\textsuperscript{120} Jessica Lovering et al., \textit{Land-use intensity of electricity production and tomorrow’s energy landscape}, PLOS ONE, July 2022, at 8, https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0270155#pone-0270155-t001.

\textsuperscript{121} U.S. Global Change Research Program, Fifth National Climate Assessment at 32-29 (2023), https://nca2023.globalchange.gov/downloads/NCA5_Ch32_Mitigation.pdf (visualizing data from Jessica Lovering et al., supra note 120 at 8).


to 29% price increases for cereal grains by 2050 due to climate change.\textsuperscript{124} These price increases would strain consumers globally, while also producing uneven regional effects.\textsuperscript{125} Moreover, while higher carbon dioxide levels may initially increase yield for certain crops at lower temperature increases, these crops will likely provide lower nutritional quality.\textsuperscript{126} For example, wheat grown at 546–586 parts per million (ppm) CO\textsubscript{2} has a 5.9–12.7% lower concentration of protein, 3.7–6.5% lower concentration of zinc, and 5.2–7.5% lower concentration of iron.\textsuperscript{127} Distributions of pests and diseases will also change, harming agricultural production in many regions.\textsuperscript{128} Such impacts will only intensify for as long as we continue to burn fossil fuels.\textsuperscript{129}

**False Claim #8: Solar development will destroy U.S. jobs.**

"Requirements for renewable energy mean that Americans’ oil and gas jobs are being sacrificed to Chinese making wind turbines and solar panels."\textsuperscript{130}

Solar development creates significantly more jobs per unit of energy generated than other types of energy production, including natural gas.\textsuperscript{131} Moreover, the number of jobs created by the renewable energy industry, including solar, is expected to far exceed the number lost due to a shift away from fossil fuels. The United States’ Fifth National Climate Assessment predicts that there will be nearly 3,000,000 new solar, wind, and transmission-related jobs by 2050 in a high electrification scenario and 6,000,000 new jobs in a 100% renewable scenario, with less than 1,000,000 fossil fuel-related jobs lost.\textsuperscript{132}


\textsuperscript{125} *Id.*; see also Climate Change 2022: Impacts, Adaptation, and Vulnerability, *supra* note 123, at 796.

\textsuperscript{126} Climate Change 2022: Impacts, Adaptation, and Vulnerability, *supra* note 123, at 717.

\textsuperscript{127} Mbow et al., *supra* note 124.

\textsuperscript{128} *Id.*; Climate Change 2022: Impacts, Adaptation, and Vulnerability, *supra* note 123, at 718.


\textsuperscript{132} U.S. GLOBAL CHANGE RESEARCH PROGRAM, *FIFTH NATIONAL CLIMATE ASSESSMENT*, *supra* note 121, at 32-31.
As of 2022, the solar industry supported approximately 346,143 U.S. jobs, including 175,302 construction jobs and 44,875 manufacturing jobs, with numbers generally increasing each year. In addition, most of these jobs cannot be outsourced. Roughly 65% of today’s U.S. solar energy jobs are in project development and 6% are in operations or maintenance, most of which cannot be exported. The number of jobs in solar energy also exceeds those in the fossil fuel generation industries. In Kentucky, for example, there are now eight times as many jobs in clean energy, including solar, as coal mining. Throughout the United States, there are roughly 5.4 times as many jobs in solar alone than in coal, and there are roughly 1.78 times as many jobs in solar than in coal, gas, and oil generation combined.

Domestic job growth in solar production and related industries has been further accelerated by recent federal legislation, including the 2021 Infrastructure Investment and Jobs Act, and the 2022 Inflation Reduction Act, which collectively provide more than $60 billion to support clean energy manufacturing, primarily with domestic supply chains. In response, manufacturers have announced plans to build multibillion dollar solar panel manufacturing facilities and related battery

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133 Id.
manufacturing facilities in the United States that will employ thousands of workers. At a smaller scale, the emerging solar recycling industry has also begun to create jobs.

**False Claim #9: Reliance on solar will make the United States dependent on China and other countries.**

“*One of the biggest mistakes the West has done on green policies to cut CO₂ emissions and trying to reduce dependence on oil and gas producing nations is that the transition to renewable energy puts the West at the mercy of China.*”

Although the United States still imports a majority of the solar panels it installs, domestic solar manufacturing is on the rise, especially following passage of the 2021 Infrastructure Investment and Jobs Act (IIJA), and the 2022 Inflation Reduction Act (IRA). In 2022, the United States manufactured approximately 10% more solar panels than in 2021. This share is likely to grow as manufacturers take advantage of IIJA and IRA incentives to open factories in the United States. In addition, as previously noted, roughly 65% of today’s U.S. solar production jobs are in project development and 6% are in operations or maintenance, most of which cannot be outsourced.

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145 INTERSTATE RENEWABLE ENERGY COUNCIL, supra note 135.
Finally, to the extent that there are concerns that solar energy will increase the United States’ dependence on China specifically, it bears noting that China is no longer a major source of solar panel imports—at least not directly.\textsuperscript{146} Tariffs imposed by the U.S. government in 2012 on Chinese-sourced solar panels have considerably diminished China’s status as a principal U.S. supplier. In 2022, approximately 77% of U.S. solar panel imports came from four countries: Vietnam (37%), Thailand (17%), Malaysia (16%) and Cambodia (7%).\textsuperscript{147} While the U.S. Department of Commerce found that companies in these four countries have been incorporating Chinese-sourced materials without paying corresponding tariffs, the U.S. Government has taken measures to crack down on noncompliance.\textsuperscript{148} In particular, the U.S. Government now requires, as of June 2024, that solar manufacturers exporting from these countries to the U.S. certify their compliance with all relevant trade rules, subject to potential audit.\textsuperscript{149}

**False Claim #10: Utility-scale solar farms destroy the value of nearby homes.**

“Solar power plants decrease property values. Over time, industrial-scale solar counties’ property values will decline and the county become less desirable, while other location’s [sic] values will increase.”\textsuperscript{150}

Data across multiple studies show that utility-scale solar projects do not have major impacts on the values of surrounding properties.\textsuperscript{151} Rather, the installation of a solar farm typically has only a minor impact on the value of homes closest to it. The most comprehensive study to date, which examined over 1.8 million home transactions near 1,500 large-scale photovoltaic projects across six states, found relatively minor impacts on property values.\textsuperscript{152} Homes located within 0.5 miles of solar farms were found to experience price reductions of 1.5%, compared to properties 2–4 miles away.\textsuperscript{153} Homes located more than 1 mile from a solar farm were found to experience no statistically significant effect on its price.\textsuperscript{154} Similarly, a 2020 study examining 400,000 transactions around 208 utility-scale solar installations in Massachusetts and Rhode Island found a 1.7% decrease in property value for homes located within 1 mile of a project.\textsuperscript{155} These declines were concentrated


\textsuperscript{147} David Feldman et al., *supra* note 143, at 68, 80.


\textsuperscript{150} *Property Values, Citizens for Responsible Solar*, https://www.citizensforresponsible-solar.org/property-values (last visited March 25, 2024).


\textsuperscript{153} Id. at 113425.

\textsuperscript{154} Id.

in suburban areas, where there is more competition for space. Yet other studies have also found that utility-scale solar farms have a greater impact on property values in areas with higher residential population density.

Yet other studies have found that solar panels can have a neutral or even a positive impact on home values. A 2018 study of solar farms in Indiana and Illinois found “no consistent negative impact” to the value of adjacent properties “that could be attributed to proximity to the adjacent solar farm.” Instead, the researchers discovered that properties within 1,320 feet of solar farms sold by an average of 1.92% more than comparable properties that were not located near any solar farms. Another 2018 study examined 956 U.S. solar projects installed before 2016 and found a majority of these projects had a neutral impact on property values. By contrast, a separate study found that the presence of a fossil fuel fired power plant within 2 miles of one’s home decreased its value by 4–7%, with the largest decreases within 1 mile and for high-capacity plants. In that study, 92% of the power plants surveyed were fueled by natural gas.

**False Claim #11: Solar energy is more expensive than fossil fuels and completely dependent on subsidies.**

“Solar farms depend entirely on subsidies from your hard earned money. When the subsidies are gone, the solar farms are abandoned!”

Unsubsidized solar energy is now generally cheaper than fossil fuels. According to the International Energy Agency’s 2020 World Energy Outlook, photovoltaic solar power is “the cheapest source of new electricity generation in most parts of the world,” and “[f]or projects with low cost financing that tap high quality resources, solar PV is now the cheapest source of electricity in history.”

Solar energy compares favorably to fossil fuels in terms of levelized cost (i.e., lifetime costs divided by lifetime energy output). According to Lazard’s April 2023 Levelized Cost of Energy Analysis, the mean unsubsidized levelized cost of utility-scale solar power is now generally cheaper than the average cost of new natural gas combined cycle power plants in the United States. The mean unsubsidized levelized cost of new solar power is lower than the average price of new natural gas combined cycle power plants in most parts of the world, and is now generally cheaper than the average price of new coal plants in most parts of the world. The mean unsubsidized levelized cost of new solar power is now generally cheaper than the average price of new nuclear plants in most parts of the world.

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156 Id. at 35.
157 Id. at 35.
160 Id.
161 Leila Al-Hamoodah et al., supra note 158.
163 Id. at 1400.
164 Id. at 1400.
large solar PV is $60/MWh.\textsuperscript{166} By comparison, the mean unsubsidized levelized cost of gas combined cycle is $70/MWh, the mean unsubsidized levelized cost of coal is $117/MWh, and the mean unsubsidized levelized cost of gas peaking is $168/MWh.\textsuperscript{167} The figure below from Lazard shows historical mean unsubsidized LCOE values for different types of utility-scale energy generation.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{lazard_lcoe.png}
\caption{Selected historical mean unsubsidized LCOE values. This graph reflects the average of the high and low LCOE for each technology in each year. The percentages on the right of the figure represent the decrease in average LCOE since 2009. \textbf{Source: Lazard.}\textsuperscript{168}}
\end{figure}

Lazard attributes the significant historical cost declines for utility-scale renewable energy generation to decreasing capital costs, improving technologies, and increased competition, among other factors.\textsuperscript{169} For solar energy, as with onshore wind energy and electric vehicle batteries, historical decreases in costs have correlated with increases in cumulative capacity and sales.\textsuperscript{170} As one example of decreasing costs of solar generation, the figure below from Inside Climate News shows a roughly 90% decline in solar module prices from 2011 to 2023.\textsuperscript{171}

\textsuperscript{167} Id.
\textsuperscript{168} Id. Reproduced with permission.
\textsuperscript{169} Id.
\textsuperscript{170} See U.S. GLOBAL CHANGE RESEARCH PROGRAM, supra note 121 at 32-15.
In addition to the many factors reducing solar’s unsubsidized LCOE, there are substantial subsidies that will further reduce cost on a subsidized basis. In particular, the Inflation Reduction Act is predicted to reduce the subsidized LCOE for solar by 20%–35% by 2030. The figure below from ICF shows the anticipated impact of the IRA on the subsidized LCOE for solar.

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172 *Id.* Reproduced with permission.

Fossil fuels also receive subsidies, albeit smaller subsidies than renewable energy currently received.\(^{175}\) In fiscal year 2022, the federal government’s tax expenditures for natural gas and petroleum subsidies were $2.1 billion.\(^{176}\)

One shortcoming of relying on levelized cost as a metric for comparing solar with natural gas and other types of legacy power plants is that levelized cost does not take into account that additional energy generation is needed to compensate for any intermittency. But even when factoring in these so-called firming costs, the subsidized and unsubsidized LCOE of stand-alone solar is lower than the levelized cost of gas peaking and cost-competitive with gas combined cycle across most of the United States.\(^{177}\) Solar-plus-storage systems are more expensive. However, when factoring in firming costs, both the subsidized and unsubsidized LCOE of solar plus storage is generally within or below the range of LCOE for gas peaking, depending on location within the United States.\(^{178}\)

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\(^{174}\) Id. Reproduced with permission.


\(^{176}\) Id. at 3-4.

\(^{177}\) Lazard, supra note 166, at 8. California is the exception, where the subsidized and unsubsidized LCOE of solar exceeds that of gas combined cycle when factoring in firming costs. Id.

\(^{178}\) Id.
False Claim #12: Solar panels don’t work in cold or cloudy climates.


Solar panels generate energy even in cold or cloudy conditions.\footnote{What happens to solar panels when it’s cloudy or raining?, SOLAR ENERGY INDUSTRIES ASSOCIATION, https://www.seia.org/initiatives/what-happens-solar-panels-when-its-cloudy-or-raining (last visited March 25, 2024); Makbul A.M. Ramli et al., On the investigation of photovoltaic output power reduction due to dust accumulation and weather conditions, 99 RENEWABLE ENERGY 836, 843 (2016), https://doi.org/10.1016/j.renene.2016.07.063.} Although cloudy weather may reduce power generation by as much as 45%, substantial energy can still be generated during those conditions.\footnote{Ramli et al., supra note 181, at 843.} Cold temperatures, however, do not reduce output at all and actually increase solar panel efficiency by increasing voltage.\footnote{Pranjal Sarmah et al., Comprehensive Analysis of Solar Panel Performance and Correlations with Meteorological Parameters, 8 ACS OMEGA 47897, 47900 (2023), https://doi.org/10.1021/acsomega.3c06442.}
False Claim #13: Solar energy is unreliable and requires 100% fossil fuel backup.

"[S]olar plants require 100% back up all the time by fossil fuels."\textsuperscript{184}

Complete reliance on solar generation, without battery storage, wind power, or long-distance transmission, would pose intermittency challenges. However, an increasing number of planned solar projects are set to include an energy storage component,\textsuperscript{185} and solar, wind and storage together can provide the majority of the country’s electricity without compromising reliability.\textsuperscript{186}

When a local service area does face diminished solar capacity, for instance during a cloudy day, wind and other renewable sources, as well as battery storage and long-distance transmission that carries power from sunnier regions can supplement energy supply, ensuring a resilient grid.\textsuperscript{187} As a result, increased reliance on solar energy need not require the construction of new natural gas plants for backup.\textsuperscript{188} The Department of Energy’s 2021 “Solar Futures Study,” for example, outlines three distinct decarbonization scenarios, each of which assumes both a massive increase in renewable energy generation and decrease in natural gas.\textsuperscript{189} Under the “business as usual” reference scenario, natural gas, oil, and steam together decrease from roughly 39% of U.S. annual electricity generation in 2020 to roughly 31% by 2035/2036 and 30% by 2049/2050; under the same scenario, solar PV increases from roughly 3.4% in 2020 to 17.6% by 2035/2036 and 27.3% by 2049/2050.\textsuperscript{190} Under the two non-reference decarbonization scenarios assessed in the studies, natural gas, oil, and steam shrink to roughly 4.7%-5.2% of annual electricity generation by 2035/2036 and 0% by 2049/2050; solar PV, meanwhile, increases to between 36.9% and 42.2% by 2035/36 and to between 40.1% and 44.8% by 2049/2050.\textsuperscript{191} Princeton University’s Net-Zero America study, which assesses pathways to achieving net-zero GHG emissions by 2050, likewise foresees significant reductions in fossil fuel consumption and generation, even when maintaining 500-1,000 GW of firm generating capacity to ensure reliability.\textsuperscript{192} Across the suite of assessed net-zero scenarios, the study assumes that all thermal coal production and consumption will cease by 2030, oil production will decline between 25% to 85% by 2050, and natural gas production will decline between 20% and 90% by 2050.\textsuperscript{193}


\textsuperscript{186} See Eric Larson et al., supra note 104, at 88 (noting that, “[t]o ensure reliability, all cases maintain 500-1,000 GW of firm generating capacity through all years,” compared to 7,400-9,900 GW for wind and solar in net-zero scenarios for 2050).


\textsuperscript{190} Id.

\textsuperscript{191} Id.

\textsuperscript{192} Eric Larson et al., supra note 104, at 88, 261.

\textsuperscript{193} Id. at 261.
California has already increased solar energy generation while decreasing natural gas utilization. In 2012, solar PV and solar thermal together accounted for only 0.9% of California’s in-state electricity generation, while natural gas accounted for roughly 70%.194 By 2022, solar had increased to 19.9% of California’s in-state electricity generation, while natural gas had decreased to 47.5%.195 Significantly, even with this increase in solar reliance, California’s grid reliability remains near, or above, the national average.196 Elsewhere in the United States, energy experts have asserted that Texas’s widespread adoption of solar generation helped prevent outages when electricity usage spiked during a recent summer heatwave.197 And although the reliability of solar and wind energy was questioned following Texas’ widespread power outages in the winter of 2021, Texas’ grid failure was primarily caused by freezing natural gas infrastructure, rather than failures at solar and wind farms, though nuclear, coal, and wind also experienced disruptions at a smaller scale.198

Energy storage also will play an important role in achieving decarbonization, while improving energy reliability. The DOE’s “Solar Futures Study” forecasts that an additional 60 GW per year of storage will be needed to achieve decarbonization.199 Fortunately, research on storage technologies has experienced significant breakthroughs in recent years. For example, sodium-ion batteries have emerged as a possible alternative to lithium-ion batteries, with sodium a much more abundant and less expensive material.200 Researchers are likewise developing more efficient utility-scale methods for storing solar energy.201

Finally, while solar energy is intermittent, multiple studies have shown that the panels themselves are highly reliable—with appreciably low degradation and failure rates, thus rarely requiring repair or replacement.202 A National Renewable Energy Laboratory (NREL) study found that the median failure rate for panels installed between 2000 to 2015 was five out of

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196 California Public Utilities Comm’n, Electric System Reliability Annual Reports, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/electric-reliability/electric-system-reliability-annual-reports (last visited March 25, 2024). In 2020, five of California’s six investor-owned utilities had frequency of sustained outages below national average when including major event days; four of six had frequency of sustained outages below national average when excluding major event days; four of six had duration of outages below national average when including major event days; and four of six had duration of outages below national average when excluding major event days. "Major event days" consist of the worst 0.63% of outage events. Id.
10,000 annually, a rate of 0.05%. Researchers have described the failure rate of residential PV inverters as “acceptable, even good,” with an inverter typically needing to be replaced only once in the lifetime of a PV system.

False Claim #14: We do not have sufficient mineral resources for large-scale solar development.

"[T]here simply aren’t enough minerals and energy on earth to make a transition to ‘renewables.’"

A 2023 study that examined 75 emissions-reduction scenarios concluded that global reserves of critical materials are likely adequate to meet future demand for electricity generation infrastructure. Production rates for many critical materials will need to grow substantially, but “[g]lobal mineral reserves should adequately meet needs posed by power sector material demand.” The United States Department of the Interior has likewise concluded that “[o]ther than perhaps short term interruptions resulting from market forces or geopolitical events, it is not anticipated that there will be any long term material constraints that would prevent the development of a significant amount of energy from photoelectric cells.”

In addition, as noted previously, new commercial ventures have formed to recycle solar panels, potentially reducing future requirements for individual raw materials. Valuable materials in solar panels, including silver, copper, and crystalline silicon, are actively sought for the development of other products, including the next generation of solar panels. Furthermore, the 2021 Infrastructure Investment and Jobs Act, and the 2022 Inflation Reduction Act, include provisions to identify and develop domestic sources of rare earth materials and other critical minerals required for our energy transition. In tandem with the rollout of these incentives, a Department of the Interior interagency working group has likewise issued more than 60 concrete recommendations for responsibly overhauling an administrative framework still largely shaped by the Mining Law of 1872. These recommendations include substantial research investments, permitting reform, and

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207 Id. at 320.
210 Wang et al., Future demand for electricity generation materials under different climate mitigation scenarios, supra note 206, at 320.
proactive public and Tribal engagement. The Department of Energy, in turn, recently announced a $150 million initiative “to advance cost effective and environmentally responsible processes” for producing critical minerals and materials in the United States.

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PART B: FALSE CLAIMS ABOUT WIND ENERGY (#15–#29)
PART B: FALSE CLAIMS ABOUT WIND ENERGY (#15–#29)

False Claim #15: Electromagnetic radiation from wind turbines poses a threat to human health.

"Recently, concerns about exposure to EMF from wind turbines, and associated electrical transmissions, have been raised at public meetings and legal proceedings."216

Multiple studies have found that the electromagnetic fields (EMFs) generated by wind turbines are lower than those generated by most common household appliances and that they easily meet rigorous international safety standards.217 For context, the average home that is not located near power lines has a background level EMF of roughly 0.2 µT.218 However, this value varies greatly depending on proximity to certain household appliances.219 For example, from a distance of 4 feet, an electric can opener’s EMF is 0.2 µT, but this value increases to 60 µT from a distance of 6 inches.220 A 2020 academic study found that the EMF generated by turbines are approximately 0.44 µT at a distance of 1 meter but less than 0.1 µT at a distance of 4 meters, as shown below.221

219 Id.
221 Alexias et al., supra note 217, at 397.
Figure 10: The EMF level, measured in microtesla (µT), is shown to drop dramatically with increase in distance from source.

Source: Alexias et al.\textsuperscript{222}

These EMF levels are not dependent on wind speeds.\textsuperscript{223}

**False Claim #16: Wind turbines frequently fall over, and blades or other components easily break off, threatening human health and safety.**

"There are many health hazards associated with living near turbines as a result of . . . broken flying blades."\textsuperscript{224}

Turbine collapse or breakage are extremely rare, and utility-scale wind turbines are fitted with safety mechanisms to survive extreme weather conditions, such as hurricanes.\textsuperscript{225} Turbine blade breakage does not pose a significant threat to humans.\textsuperscript{226} The Department of Energy has noted that, although the risk of turbine blades becoming detached during operation "was a concern in the early years of the wind industry," such failures "are virtually non-existent on today's turbines due to better engineering and the use of sensors."\textsuperscript{227} Turning to all turbine blade failures, rather than just turbine blade detachment, a

\textsuperscript{222} Id.
\textsuperscript{223} Id. at 398.
\textsuperscript{224} No Wind Turbines! Get the Facts!, SAVE PIATT COUNTY, http://www.savepiattcounty.org/ (last visited March 25, 2024).
2015 study found that wind turbine blades fail at a rate of approximately 0.54% per year globally.\textsuperscript{228} The Department of Energy has further reported that “catastrophic wind turbine failures . . . are considered rare events with fewer than 40 incidents identified in the modern turbine fleet of more than 40,000 turbines installed in the United States as of 2014.”\textsuperscript{229} When looking at deaths per terawatt-hour of energy produced, the mortality rate from wind energy pales in comparison to the risks associated with fossil fuels. Brown coal causes 32.72 human deaths per terawatt-hour, while black coal causes 24.6 human deaths, oil causes 18.4 human deaths, natural gas causes 2.8 human deaths, and wind energy causes only 0.04 human deaths.\textsuperscript{230}

![Death rates per unit of electricity production](source: Hannah Ritchie, Our World in Data)\textsuperscript{231}

\begin{itemize}
\item \textsuperscript{230} Hannah Ritchie, \textit{supra} note 13.
\item \textsuperscript{231} \textit{Id}. 
\end{itemize}
False Claim #17: Low-frequency noise from wind turbines harms human health and causes “wind turbine syndrome.”

“As wind turbines spring up like mushrooms around people’s homes, Wind Turbine Syndrome has become an industrial plague.”

Multiple studies have concluded that there is no direct causal correlation between noise from wind turbines and human health. Rather, studies have found that individual cases of headache or malaise in proximity to new wind turbines are most likely the result of personal attitudes toward and annoyance regarding the turbines.

Accounts of “wind turbine syndrome” have received significant criticism from the scientific community, and public-health experts argue that any symptoms experienced are likely psychosomatic. One historical study looked at complaints filed in relation to 51 Australian wind farms from 1993 to 2012. Prior to 2009, complaints related to health and noise were rare, despite the fact that many small and large wind farms were already in operation. However, following the coining of the phrase “wind turbine syndrome” in a self-published book that year, there was a dramatic spike in complaints.

False Claim #18: Shadow flicker from wind turbines can trigger seizures in people with epilepsy.

“Wind farms are more than just an eyesore. They can cause epileptic fits.”

Even at its peak, shadow flicker from wind turbines typically remains far weaker than what is known to trigger seizures in people with epilepsy.

232 Calvin Luther Martin, Your Guide to Wind Turbine Syndrome... A Roadmap to this Complicated Subject, NATIONAL WIND WATCH (July 2010), https://docs.wind-watch.org/WTSguide.pdf.
234 Irene van Kamp et al., supra note 233.
237 Id.
238 Id.
A 2021 academic study found that wind turbines operate between 0.5 to 1 Hz, much lower than the threshold frequency of 3 Hz typically required to cause a seizure.\(^{241}\) Similarly, a 2012 report prepared for the Massachusetts Department of Environmental Protection found that shadow flicker frequencies from wind turbines are “usually in the range of 0.3–1.0 Hz, which is outside of the range of seizure thresholds according to the National Resource Council and the Epilepsy Foundation.”\(^{242}\) If shadow flicker were to reach 3 Hz, the probability of causing a seizure in a member of the photosensitive population would be approximately 1.7/100,000.\(^{243}\)

Additional public-health studies have likewise found that wind turbines do not cause seizures.\(^{244}\) Wind turbines with three blades, for example, would need to rotate at a speed of 60 rpm to cause a seizure.\(^{245}\) However, modern turbines typically operate at maximum speeds between 15 and 17 rpm, depending on model, well below the 60 rpm threshold.\(^{246}\)

**False Claim #19: Wind turbines are a major threat to birds, bats, and other wildlife.**

“The evidence is clear . . . that wind turbines present yet another threat to the lives of birds and bats.”\(^{247}\)

According to the National Audubon Society, two-thirds of all North American bird species are at heightened risk of extinction due to climate change.\(^{248}\) Wildfires will destroy the nesting grounds of many species,\(^{249}\) while extreme heatwaves will render their typical habitats uninhabitable.\(^{250}\) For example, the American Goldfinch is projected to lose 65% of its range under a scenario of 3 degrees Celsius global warming, while the Allen’s Hummingbird is projected to lose 64% of its range.\(^{251}\)

By contrast, wind power is a relatively minor source of mortality for birds. The U.S. Fish and Wildlife Service has estimated that, throughout the United States, cats kill an average of 2.4 billion birds per year, and collisions with building glass kill an average of 599 million birds, while wind turbines kill an average of 234,000 birds per year.\(^{252}\) These mortality figures for wind impacts rely on studies dating back to 2013 or 2014 and may be outdated due to the fact that there were fewer wind


\(^{243}\) Id.


\(^{245}\) Knopper et al., supra note 244 at 14.

\(^{246}\) Id.


\(^{251}\) Id.

turbines 10 years ago than there are today.253 However, research has found that wind power causes far fewer bird deaths than fossil fuels per unit of energy output, a metric that is not sensitive to the total number of wind turbines installed. While fossil fuels cause 5.2 avian fatalities per GWh, wind turbines cause only 0.3–0.4 avian fatalities per GWh.254

![Leading anthropogenic causes of bird mortality in the United States](image)

**Figure 12: Leading anthropogenic causes of deaths to birds in the United States.**

*Source: Boston University Institute for Global Sustainability.*

In addition, actionable steps can be taken to reduce bird and bat fatalities from wind turbines. To provide one example, most bird deaths occur when turbines are sited near nesting places. Proper siting of turbines that takes into account where birds nest, feed and mate, as well as where they stop when migrating, has proved successful at reducing fatalities.256

To provide a second example, the wind turbine components that pose the greatest risk to birds are the blades and tower.257 The relatively simple action of painting the tower black has been shown to reduce deaths by roughly 48%, while painting one of the blades black has reduced deaths by 70%. Other successful methods promoting the safe passage of birds and

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253 *Do wind turbines kill birds?* MIT Climate Portal (Aug. 17, 2023), https://climate.mit.edu/ask-mit/do-wind-turbines-kill-birds (noting that the cited studies were published in 2013 and 2014, and the numbers are likely to be higher today because more wind farms have been built since then).

254 Benjamin K. Sovacool, *The avian benefits of wind energy: A 2009 update*, 49 RENEWABLE ENERGY 19, 19 (2013), https://doi.org/10.1016/j.renene.2012.01.074. The Sovacool study explains that fossil fuels cause avian fatalities upstream during coal mining, through collision and electrocution with operating plant equipment, and indirectly through acid rain, mercury pollution, and climate change. *Id.* at 21. The study is based on operating performance in the United States and Europe. *Id.* at 19.


256 Sovacool, supra note 254 at 19-20.

257 *Id.* at 23.
bats include slowing or stopping turbine motors when vulnerable species are present, in order to reduce the likelihood of collisions.\textsuperscript{258} Deployment of this method in Wyoming has contributed to an 80\% decline in eagle fatalities.\textsuperscript{259} New strategies under development include the use of artificial intelligence and surveillance to monitor nearby bird and bat activity, which can help inform when to slow or stop turbine motors. One preventative strategy involves producing visual and auditory outputs that deter vulnerable bird and bat species from flying near the turbines altogether.\textsuperscript{260} Overall, though it remains difficult to eliminate the risk of collisions entirely, wind power can ultimately help to protect bird and bat populations by displacing fossil fuels and mitigating climate change impacts.\textsuperscript{261}

**False Claim #20: Offshore wind development is harmful to whales and other marine life.\textsuperscript{262}**

"Record numbers of endangered whales [are] being killed by windfarms off America’s East Coast\textsuperscript{263}"

When properly sited, offshore wind farms need not pose a serious risk of harm to whales or other marine life. During installation, the impact from construction noise can be mitigated by implementing seasonal restrictions on certain activities that coincide with whale migration. Once operational, wind turbines generate far less low-frequency sound than ships do, and there is no evidence that noise from turbines causes negative impacts to marine species populations.\textsuperscript{264} There has been considerable attention to how offshore wind development, including noise from pile-driving during construction, affects the critically endangered North Atlantic right whale, which has a total population of roughly 360.\textsuperscript{265} But the main causes of mortality for right whales are vessel strikes (75\% of anthropogenic deaths) and entanglements in


\textsuperscript{259} Christopher J.W. McClure et al., *Eagle fatalities are reduced by automated curtailment of wind turbines*, 58 BRITISH ECOLOGICAL SOC’Y. 446, 450-451 (2021), https://doi.org/10.1111/1365-2664.13831.


\textsuperscript{262} While outside the scope of this report, it bears noting that journalists have uncovered financial connections between fossil fuel interest groups and certain groups alleging that offshore wind development leads to considerable negative impacts on whales. See Marvell, supra note 11.


fishing gear—not anything related to offshore wind development. Critically, the National Oceanic and Atmospheric Administration (NOAA) has also found no link between offshore wind surveys or development on whale deaths.

Moreover, any impacts to the North Atlantic right whale can be avoided or greatly minimized through proper planning. For example, in 2019, the developer of the 800-MW Vineyard Wind project entered into an agreement with three environmental organizations, which established seasonal restrictions on pile-driving during construction (to avoid excessive noise when right whales are present), as well as strict limits on vessel speeds during the operational phase (to avoid vessel strikes), among other measures. In the final environmental impact statement for the project, the U.S. Bureau of Ocean Energy Management (BOEM) found that, “[g]iven the implementation of Project-specific measures, BOEM anticipates that vessel strikes as a result of [the project] alone are highly unlikely and that impacts on marine mammal individuals . . . would be expected to be minor; as such, no population-level impacts would be expected.” BOEM also found that project installation would be unlikely to cause noise-related impacts to right whales, due to the time of year during which construction activities would take place.

Offshore wind development can have benefits for other marine species. For example, the base of an offshore wind turbine may function as an artificial reef, creating new habitats for native fish species.

By contrast, offshore oil and gas drilling routinely harms marine life, while posing a persistent risk of catastrophic outcomes. Sonar used for offshore oil and gas exploration emits much stronger pulses of sound than sonar used for wind farm surveying. The 2010 Deepwater Horizon oil spill killed millions of marine animals, including as many as 800,000 birds. More broadly, carbon dioxide emissions from fossil fuel use are making the ocean increasingly acidic, which inhibits shellfish and corals from developing and maintaining calcium carbonate shells and exoskeletons. Finally, climate change is expected to have “long-term, high-consequence impacts” on whales and other marine mammals, including “increased energetic costs associated with altered migration routes, reduction of suitable breeding and/or foraging habitat, and reduced individual fitness, particularly juveniles.”


269 Vineyard Wind Final EIS, supra note 266, at 3-95.

270 Id. at 3-91.


272 Id., supra note 11.

273 Id.


276 Vineyard Wind Final EIS, supra note 266, at 3-85.
False Claim #21: Producing and transporting wind turbine components releases more carbon dioxide than burning fossil fuels.

"Windmills are perhaps the worst boondoggle . . . because they require much more high quality energy to manufacture, install, maintain, and back up than [they] will ever produce."277

On a lifecycle basis, wind power emits far less carbon dioxide than fossil fuels per kilowatt-hour of energy generated.278 According to the National Renewable Energy Laboratory (NREL), the average lifecycle emissions of offshore and onshore wind turbines is 13 g CO$_2$-eq/KWh.279 Lifecycle emissions for fossil fuels are much higher, with natural gas and coal releasing 486 g CO$_2$-eq/KWh and 1001 g CO$_2$-eq/KWh emissions, respectively.280 In other words, the average lifecycle emissions of wind energy is roughly 1/77th that of coal.281

Manufacturing accounts for only a small percentage (2.41%) of the lifecycle emissions for wind power turbines.282 Most turbine emissions come from transportation, which accounts for over 90% of emissions for both offshore and onshore operations.283 Once operational, wind turbines create clean, emissions-free energy that offsets the carbon dioxide emissions associated with production and transportation.284

False Claim #22: Wind turbines will generate an unsustainable amount of waste.

"This clean, green energy is not so clean and not so green . . . [i]t’s just more waste going in our landfills."285

Roughly 80%-85% of modern wind turbine materials, including the steel turbine tower, can be recycled.286 Turbine blades,
which contain fiberglass composite materials are more difficult to recycle, but new techniques are being explored. A recent breakthrough supported by the Department of Energy, for example, enabled all turbine components to be recycled. Private companies have begun developing turbine blade recycling plants to ensure that wind turbine production is entirely circular. One company’s analysis found that total cumulative waste from decommissioned turbine blades could exceed 14 million tons by the early 2040s. This is not insignificant. However, Nature Physics has projected that fossil fuel-based power generation is expected to produce roughly 45,550 million metric tons of coal ash alone by 2050, along with 249 million metric tons of oily sludge. These figures far exceed the anticipated waste from wind turbine blades, and both coal ash and oily sludge are known to be toxic. For context, roughly 600 million tons of construction and demolition debris were generated in the United States in 2018 across all sectors.

False Claim #23: Wind turbines take up too much land.

"The wind’s low power density means massive materials and land/sea area requirements."

Princeton University’s 2021 report, Net-Zero America, concluded that the wind turbines needed for the United States to reach net-zero emissions by 2050 will have a direct footprint (i.e. the area covered by turbine bases and access roads) of between 603,678 and 2,479,208 acres. This is notably less than the 4.4 million acres currently used for natural gas extraction and the 3.5 million acres for oil extraction.

Moreover, depending on the location and the technology used, wind turbines can also require less land per kilowatt-hour generated than fossil fuels. A report by the United Nations Economic Commission for Europe (UNECE) found that total land occupation (agriculture and urban) for wind power ranged from 0.3–1 m²/kWh for 2022. The exact value depends

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291 Miritz et al., supra note 55, at 1376.
292 Id.
293 Id.
296 Eric Larson et al., supra note 104, at 245. The report predicts that the “total wind farm area” will be significantly larger, but these numbers include the entire visual footprint of wind farms.
299 Id.
on the type of wind tower, onshore or offshore siting, and the particular location of the turbine.299 By comparison, natural gas values ranged from 0.6–3.3 m²/KWh, and coal values from 7.2–23.8 m²/KWh.300 The UNECE report notes that these calculations do not include carbon capture and storage (CCS), which, if implemented, would decrease emissions but increase land use.301

Wind energy also uses far less land than biomass. Dedicated biomass consumes an average of 160,000 hectares of land per terawatt-hour per year.302 By contrast, the land-use intensity of wind energy is only 170 hectares per terawatt-hour per year when looking at the direct footprint of wind or 15,000 hectares per terawatt-hour per year when including space between turbines.303

![Figure 13: Average land-use intensity of electricity, measured in hectares per terawatt-hour per year.](source)

Fossil fuel generation also has more harmful and enduring impacts on the land that it uses. Spills frequently occur as a result of the extraction, transportation, and distribution of oil and natural gas, causing soil and water damage. A 2017 study found that between 2% and 16% of unconventional oil and gas wells reported a spill each year, with more spills in some

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299 Id.
300 Id.
301 Id.
302 Jessica Lovering et al., supra note 120, at 8.
303 Id.
304 U.S. Global Change Research Program, supra note 121 at 32-29 (visualizing data from Jessica Lovering et al., supra note 120 at 8).
states than others. Reclamation is difficult in areas surrounding extraction sites because of frequent leakage. The land involved often suffers long-term damage and can only be used for limited purposes. Moreover, abandoned coal mines and orphaned oil and gas wells can continue to threaten public health by contaminating groundwater, emitting methane and other noxious gases, and, in the case of abandoned coal strip mines, even result in continuing risk from falling boulders. There are currently over 130,000 documented orphaned oil and gas wells in the United States, and nearly 40% of Kentucky’s active coal mines are “functionally abandoned.”

By contrast, utility-scale wind farms can be incorporated into America’s pasture and cropland with significantly less disturbance. Wind farms directly occupy relatively small amounts of land. According to the Department of Energy, powering 35% of our national electric grid through wind turbines would require 3,200 km² (790,000 acres) of land, a small fraction of the United States’ 2.3 billion acres of land. Furthermore, there is ample space for additional land uses within wind farms: the National Renewable Energy Laboratory estimates that about 98% of the area in a wind farm is available for agriculture or other uses. Moreover, plant and animal species can safely grow and roam directly up to a turbine’s base. This can help native species to flourish, as well as allowing farmers to continue cultivating crops and grazing animals after wind projects are installed. And reclamation of wind (and solar) energy sites can begin as soon as plants begin operation, because wind and solar require only small amount of soil disturbance compared to other energy sources.

Finally, climate change produced by burning fossil fuels directly harms forests, oceans, crops, and wildlife, including by causing wildfires, algal blooms, droughts, and extreme weather events that mar the visual landscape. Wind energy, in contrast, further protects local landscapes by mitigating climate impacts.

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307 Id. note 308.
310 Bruggers, supra note 308.
312 Paul Denholm et al., Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035 at 51, NAT’L RENEWABLE ENERGY LABORATORY, 2022, https://www.nrel.gov/docs/fy22osti/81644.pdf.
False Claim #24: Wind power, particularly offshore wind power, is too expensive.

"Wind farms ... cannot produce electricity competitively and require massive government subsidies for both installation and subsequent operation. Rate payers are hit with a double whammy, higher electric rates and higher taxes to pay the subsidies."316

In the United States, onshore wind has the lowest unsubsidized levelized cost of energy (LCOE) of all utility-scale energy sources. Onshore wind’s mean unsubsidized LCOE is $50/MWh, substantially lower than the mean unsubsidized LCOE of gas combined cycle ($70/MWh), coal ($117/MWh), and gas peaking ($168/MWh).317 And, as the figure below from Lazard shows, although offshore wind power is more expensive than gas combined cycle when subsidies are not taken into account, the unsubsidized mean LCOE for offshore wind ($106) is still lower than that of gas peaking and coal.318

![Figure 14](image-url)  
*Figure 14: The range of unsubsidized LCOE for utility-scale energy sources across various cost of capital scenarios, highlighting the mean unsubsidized LCOE as of April 2023. "IRR" stands for "internal rate of return" and "WACC" stands for "weighted average cost of capital."*  
*Source: Lazard.*319

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317 Lazard, supra note 166, at 2, 6, 9.
318 Id.
319 Id. Reproduced with permission.
In addition, the LCOE for offshore wind power has declined substantially over the past decade.\textsuperscript{320} The Department of Energy’s most recent offshore wind market report estimates that the LCOE for a fixed-bottom offshore wind project beginning operations in 2022 would have been roughly 50% lower than one beginning operations in 2014, despite a 6% increase in costs compared to a 2021 cost estimate.\textsuperscript{321} Researchers further project that the average LCOE for offshore wind energy will fall to $63/MWh by 2030.\textsuperscript{322}

Due in large part to this dramatic price decline, deployment of offshore wind has surged in recent years, both domestically and globally. By the end of 2022, global capacity had reached 59,009 MW, up roughly 18% from 2021.\textsuperscript{323} As of the end of May 2023, the pipeline of U.S. offshore wind projects in development and operation was estimated to represent 52,687 MW of wind energy capacity, a 15% growth compared to May 2022.\textsuperscript{324} It bears noting, however, that several offshore wind projects have been removed from the U.S. offshore wind pipeline since May 2023 as a result of project cancellation.\textsuperscript{325} This includes Ocean Wind I and II, canceled in October 2023, which were anticipated to deliver over 2,200 MW of wind energy capacity.\textsuperscript{326}

Once operational, offshore wind turbines generate more energy and greater revenues than onshore wind farms, due to higher and steadier wind speeds; they also have the advantage of generating energy closer to many U.S. coastal population centers, thus reducing the need for long-distance transmission.\textsuperscript{327} According to the European Wind Energy Association, while the average onshore wind turbine generates enough energy to power 1,500 homes, the average offshore turbine can power more than 3,300 homes.\textsuperscript{328} Moreover, when factoring in costs associated with climate change and human health impacts, offshore wind becomes even less expensive compared to many fossil fuel energy sources.\textsuperscript{329}

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\textsuperscript{321} Musial et al., supra note 320, at xiii, 81-83.

\textsuperscript{322} Id.


\textsuperscript{324} Musial et al. supra note 323, at viii.


\textsuperscript{326} Ocean Wind 2, https://oceanwindtwo.com/ (last visited March 25, 2024).


\textsuperscript{328} Laura Small et al., supra note 327, at 3.

False Claim #25: Wind turbines are bad for farmers and rural communities.

"The construction of industrial wind turbines affects aquifers, water flow, tile lines, soil erosion, soil compaction, air pressure and current. In essence, it is destruction of the best soil in the world, the farmland that the generations before us were proud of and left for us to feed the world with."³³⁰

Wind power offers farmers the opportunity to earn additional income from leasing out their land, while also growing crops or grazing livestock.³³¹ As a result, many farmers view wind turbines as beneficial for their farmland and the local community.³³² And wind farms leave ample space for continued agricultural use: the National Renewable Energy Laboratory estimates that about 98% of the area in a typical wind farm is available for agriculture or other uses.³³³ The New York Farm Bureau has stated that "[w]ind turbines are geared towards continued farming activities, because wind turbines are typically spaced one acre apart."³³⁴ Moreover, "[l]ivestock are unaffected by the presence of wind turbines and will graze right up to the base of wind turbines."³³⁵

The additional income from lease payments can help farmers keep their land in production.³³⁶ One 2017 University of Michigan study found that farmers with turbines tend to invest twice as much in their farms as farmers without wind turbines.³³⁷ In addition, property tax payments from utility-scale wind projects provide revenue to rural communities for investing in schools, roads, and bridges.³³⁸

Farmers with turbines also appear more confident that they will continue to own their farms at the time of death. In the University of Michigan study, survey results showed 80% of those with turbines had a plan of succession for their farm, while only 62% of those without a turbine had a succession plan.³³⁹ The researchers concluded that this difference was likely due to added income the wind turbine provided.³⁴⁰

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³³⁰ Save Piatt County, supra note 224.
³³³ Paul Denholm et al., supra note 312 at 51.
³³⁵ Id.; see also id. ("Wind turbines are sturdy enough to withstand cattle using them as rubbing posts or for shade.").
³³⁷ Mills, supra note 332, at 219-221.
³³⁸ Wind energy’s economic impacts to communities, supra note 331.
³³⁹ Mills, supra note 332, at 215, 219.
³⁴⁰ Id. at 215, 219-220.
Wind farms can likewise contribute to agricultural productivity. A 2019 study of Gobi Desert wind farms, from China’s Zhejiang University, found that turbine proximity made local vegetation “more metabolically efficient, with higher community coverage, density, and AGB [aboveground biomass].” Recent research from Iowa State’s Agronomy department posits that related benefits to agricultural yields might stem from increased photosynthesis capacity as turbines draw additional carbon dioxide out of the soil. Further studies suggest that wind turbines may even increase crop yields on neighboring farms, by minimizing harmful temperature extremes in the surrounding area. Moreover, while recognizing that wind farm installation can contribute to short-term soil degradation, a 2020 analysis from Brazil’s Universidade Federal do Ceará concluded that these installations produce impacts less intense than those “caused by agricultural use and rainfall in the same period” and that local farmers found it possible “to reconcile agriculture and wind power generation without major repercussions on rural lots.”

False Claim #26: Wind energy is bad for U.S. jobs.

"Subsidised wind and solar destroy far more jobs than they ever 'create"\footnote{345}

Wind power is a fast-growing industry, creating many U.S. jobs. In 2021, wind energy production employed roughly 120,000 U.S. workers, creating roughly 5,400 new jobs (up 4.7%) since 2019. The Department of Energy suggests that this sector could employ as many as 600,000 U.S. workers by 2050. As noted previously, the United States’ Fifth National Climate Assessment predicts that there will be nearly 3,000,000 new solar, wind, and transmission-related jobs by 2050 in a high electrification scenario and 6,000,000 new jobs in a 100% renewable scenario, with less than 1,000,000 fossil fuel-related jobs lost.\footnote{348}

\begin{footnotesize}
\begin{enumerate}
\item Kang Xu et al., \textit{Positive Ecological Effects of Wind Farms on Vegetation in China’s Gobi Desert}, \textit{Sci. Reports} 9, 6341 (2019)\footnote{341} https://www.nature.com/articles/s41598-019-42569-0.\footnote{341}
\item Daniel T. Kaffine, \textit{Microclimate effects of wind farms on local crop yields}, 96 \textit{J. Env.’t. Econ. Mgmt.} 159, 159-160 (2019), https://doi.org/10.1016/j.jeem.2019.06.001.\footnote{343}
\item Manoel Fortunato Sobrinho Júnior et al., \textit{Soil Use and Occupation of Wind Farm Agricultural Areas}, 19 \textit{MERCATOR - REVISTA DE GEOGRAFIA DA UFC}, 1, 3, (2020), https://www.redalyc.org/journal/2736/273664287012/273664287012.pdf.\footnote{344}
\item Wind Vision: A New Era for Wind Power in the United States, supra note 229, at 139.\footnote{347}
\item U.S. Global Change Research Program, \textit{supra} note 121, at 32-31.\footnote{348}
\end{enumerate}
\end{footnotesize}
Figure 15: Energy employment from 2020 to 2050 for Alternative Net-Zero Pathways.

*Source: U.S. Global Change Research Program.*

Most of the current domestic jobs are in manufacturing. Over 500 U.S. manufacturing facilities now specialize in producing components for wind power generation. For turbines installed in the United States, approximately 70% of tower manufacturing and 80% of nacelle assembly also occurs domestically. Furthermore, the U.S. Bureau of Labor Statistics identified wind turbine service technicians as the fastest growing occupation between 2022 and 2023, growing roughly 45% in size during that time.

**False Claim #27: Wind turbines destroy nearby property values.**

"The presence of a wind power facility is likely to drive down the value of surrounding properties."

Multiple academic studies have assessed the impact of wind turbines on property values. Most recently, a March 2024 study found that having a wind turbine in a home’s viewshed reduces the sales price by 1.12% on average. The study found that the negative impact of turbines on property values was primarily observed for urban, rather than rural, properties, and

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349 *Id.*


352 *Id.* The nacelle is the housing that holds the gearbox, generator, drivetrain, and brake assembly.


that any negative impact on property values disappeared within ten years after turbine installation.\textsuperscript{356} The study also found that turbine installations have become less disruptive to home values over time: the researchers found no statistically significant impact on home values for turbines installed after 2017 and stated that the 1.12% average impact “is larger than the effect one would expect for recent and future installations.”\textsuperscript{357}

For comparison, a December 2023 study found evidence that, when a wind development is announced within one mile of a home, prices decline by up to 11% compared to homes three to five miles away.\textsuperscript{358} However, home prices return to within 2% of inflation-adjusted pre-announcement levels roughly five years after the project enters operation.\textsuperscript{359} The study found that the population of the county mattered: the decrease was roughly 15% in counties with over 250,000 people but statistically insignificant in counties with fewer than 250,000 people.\textsuperscript{360} The study also found no statistically-significant adverse impacts on home sale prices outside of 1.25 miles from the nearest turbine.\textsuperscript{361}

An earlier study from 2021 testing how turbine size affects property values at varying distances found that, on average, nearby turbine installation decreases home value by 1.8%.\textsuperscript{362} The study also found that the farther a turbine was placed from a home, the less impact it had on property value.\textsuperscript{363} The greatest impact, a price drop of 8.3%, occurred when a large turbine (>150 meters) was placed within 750 meters of a home.\textsuperscript{364} The greatest impact from a medium sized turbine (50–150 meters) was 3.4%.\textsuperscript{365} Beyond 2,250 meters, moreover, the 2021 study found no discernible price impact from turbines.\textsuperscript{366} A separate study found no impact beyond 3 km.\textsuperscript{367} The figure below shows how, for the 2021 study, size and distance of a turbine impacted property value.\textsuperscript{368}
Another academic study of roughly 50,000 Rhode Island single-family home transactions located within 5 miles of a turbine site found no statistically significant price impact. While yet another academic study of roughly 50,000 home transactions (spread across nine states) within 10 miles of a turbine site likewise found no statistically significant evidence of a price change. By contrast, a 2011 paper found that the presence of a fossil fuel fired power plant within 2 miles of one’s home decreased its value by 4–7%. Among the fossil fuel power plants in the study sample, 92% were natural gas plants.

Finally, these impacts can be mitigated. For example, multiple studies recommend clustering turbines within wind farms. One of these studies found that adding a turbine within two kilometers of an existing turbine had a statistically insignificant

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369 Id.
373 Id. at 1400.
374 Cathrine Jensen et al., supra note 367, at 51; Martijn Dröes et al., supra note 362, at 7.
impact on house prices. It bears noting, however, that turbines must be spaced in such a way as to minimize wake interference, the phenomenon where an upstream wind turbine interferes with the production of a downstream turbine.

**False Claim 28: Wind energy is unreliable.**

"[B]ecause of the wind's intermittency and high variability, they do next to nothing to reduce the need for other fuels."

As with solar energy, complete reliance on wind energy would pose intermittency challenges. However, wind, solar, and storage together can provide the majority of the country’s electricity without compromising reliability. Hydropower has also been found to support wind and solar by compensating for intermittency in those sources. Moreover, building more long-distance transmission infrastructure can enable greater reliance on wind and solar generation, and linking offshore wind projects through offshore transmission networks is also expected to enhance grid reliability.

A National Renewable Energy Laboratory report concluded that “wind power can support power system reliability” by providing “active power controls,” which are mechanisms for balancing the power generated by wind farms with the power consumed on the electricity grid. And although the reliability of wind and solar energy was questioned following Texas’ widespread power outages in the winter of 2021, Texas’ grid failure was primarily caused by freezing natural gas infrastructure, rather than failures at wind and solar farms, though nuclear, coal, and wind also experienced disruptions at a smaller scale.

Wind energy has already been successfully incorporated into the United States’ electric grid at significant scale. Domestic energy production from wind more than tripled between 2011 and 2022, from 120 billion kilowatt-hours (2.9% of total

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375 Martijn Dröes et al., *supra* note 362, at 7.
377 *Id.*
378 *See* Eric Larson et al., *supra* note 104, at 88 (noting that, “[t]o ensure reliability, all cases maintain 500-1,000 GW of firm generating capacity through all years,” compared to 7,400-9,900 GW for wind and solar in net-zero scenarios for 2050).
379 Rui Shan et al., *Complementary relationship between small-hydropower and increasing penetration of solar photovoltaics: Evidence from CAISO*, 155 RENEWABLE ENERGY 1139, 1140 (2020).
380 *See* id. at 97 (noting that “[l]imiting inter-regional transmission capacity to a maximum of 2x current capacity . . . leads to slightly more gas w/ [carbon capture] and less wind”).
energy production) to 435 billion kilowatt-hours (10.3% of total energy production).\textsuperscript{386} Some states have seen even more rapid growth. In 2021, wind energy accounted for 58% of electricity production in Iowa, and 43% of electricity production in Kansas.\textsuperscript{387}

Wind power has enabled Iowa not only to reduce energy costs, but to generate additional revenue by selling excess power to neighboring states during shortages.\textsuperscript{388} Today, Iowa is considered one of the states with the most reliable energy systems.\textsuperscript{389} In California, electricity generated from wind power increased from roughly 3% in 2009, to roughly 7% in 2022. Electricity generated from natural gas declined from roughly 56% in 2009, to roughly 47% in 2022.\textsuperscript{390} Yet even with this increased reliance on wind power, California’s grid reliability has remained consistent, and largely above national averages.\textsuperscript{391} California has even been able to briefly meet 103% of its energy demands exclusively from renewable sources, demonstrating that a large economy can by powered by renewable energy.\textsuperscript{392} The UK has also made substantial progress utilizing wind power, which was responsible for 26.8% of overall energy production in 2022, and which helped stave off the worse impacts from the energy crisis following Russia’s invasion of Ukraine.\textsuperscript{393}

### False Claim 29: Wind turbines are very noisy.

"Noise created by commercial-scale wind turbines has become a major concern around the world as wind power development continues to proliferate."\textsuperscript{394}

In a 2021 environmental impact statement for the 120-turbine, 500-MW Rail Tie Wind Project in Wyoming, which is anticipated to serve the energy needs of 180,000 households, the Department of Energy found that noise generated by site operations likely would not exceed 55 A-weighted decibels (dBA),\textsuperscript{395} except in a worst-case scenario in which noise “might reach slightly above 55 dBA.”\textsuperscript{396} The DOE provides as a point of comparison that sounds at 60 dBA resemble those of a

\textsuperscript{386} Id.
residential air conditioner 20 feet away, whereas sounds at 50 dBA resemble those of a residential air conditioner 50 feet away.\textsuperscript{397}

When measured from inside a building located 124–330 meters from a wind turbine, noise produced by the turbine’s motion has ranged from 30.7–43.4 decibels.\textsuperscript{398} When measured from outside at the same distance, noise level has ranged from 38.2–50.0 decibels in summer, and 38.9–44.6 decibels in winter.\textsuperscript{399} For context, a soft whisper is 30 decibels, a refrigerator hum is 40 decibels, and a typical conversation takes place at 60 decibels.\textsuperscript{400} The CDC has set 70 decibels as the cutoff at which prolonged exposure can cause annoyance and hearing damage.\textsuperscript{401} Also, noise has substantially decreased with turbine innovation: while earlier turbines created a steady noise from gears turning, modern turbines have been designed to insulate these sounds.\textsuperscript{402}

\textsuperscript{397} Id. at 3-104.
\textsuperscript{398} Chun-Hsiang Chiu et al., \textit{Effects of Low-Frequency Noise from Wind Turbines on Heart Rate Variability in Healthy Individuals}, 11 SCI. REP. 17817, 17822 (2021), https://doi.org/10.1038/s41598-021-97107-8.
\textsuperscript{399} Id.
\textsuperscript{401} Id.
PART C: FALSE CLAIMS ABOUT ELECTRIC VEHICLES (#30-#33)
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False Claim #30: Electric vehicles have a net harmful effect on climate change.

“Contrary to vociferous assertions, EVs are no friends of the environment.”

EVs are essential to reducing greenhouse gas (GHG) emissions and the use of fossil fuels that cause those emissions. The Environmental Protection Agency has found that EVs typically have lower lifecycle emissions than traditional gasoline-powered cars, even when taking into account the emissions released when manufacturing EVs and generating power to charge them. The Intergovernmental Panel on Climate Change has further explained that “[t]he extent to which EV deployment can decrease emissions by replacing internal combustion engine-based vehicles depends on the generation mix of the electric grid although, even with current grids, EVs reduce emissions in almost all cases.” The key reason why EVs reduce emissions in almost all cases is that they are inherently more efficient than conventional gasoline-powered vehicles: EVs convert over 77% of electrical energy to power at the wheels, whereas conventional vehicles only convert roughly 12%–30% of the energy in gasoline to power at the wheels.

Assuming average U.S. grid emissions, the average lifecycle GHGs associated with a gasoline-powered car that gets 30.7 miles per gallon are more than twice as high as those of an EV with a 300-mile range. The figure below from the EPA shows that the lifecycle GHGs for the gasoline-powered car under this scenario are between 350 and 400 grams/mile, whereas the lifecycle GHGs for the EV are only slightly above 150 grams/mile.

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405 Electric Vehicle Myths, supra note 18.


408 Electric Vehicle Myths, supra note 18.

409 Id.
Most importantly, EVs’ lack of tailpipe emissions and heightened efficiency more than offset the emissions required to manufacture EV batteries: these emissions are offset within 1.4-1.5 years for electric sedans, and within 1.6-1.9 years for electric SUVs. These reduced tailpipe emissions not only help to stabilize our climate, but also improve air quality, bringing multiple health benefits including reduced rates of childhood asthma, particularly in urban areas.

The emissions offset by transitioning to EVs vary based on the carbon intensity of the energy grid. A study from Munich’s Universität der Bundeswehr found EVs to have reduced emissions by 72% when powered by Germany’s electric grid, which drew 23% of its electricity from renewable energy in 2021. But the researchers projected that a 100% renewable energy grid would have allowed EVs to reduce emissions by as much as 97%. And the U.S. grid is getting cleaner over time, with a 44% reduction in power sector emissions from 2005 to 2023, meaning that EVs are having an increasingly positive impact on U.S. emissions. For those drivers in the United States who would like to ensure that they are charging their

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410 Id.
411 Maxwell Woody et al., The Role of Pickup Truck Electrification in the Decarbonization of Light-Duty Vehicles, 17 ENVIRON. RES. (Mar. 1, 2022), https://iopscience.iop.org/article/10.1088/1748-9326/ac5142. These figures assume “a business-as-usual scenario which includes policies in place as of June 2020 with no projected policy changes, resulting in a grid that is 50% less carbon intensive in 2035 compared to 2005.”
413 Id.; see also Paul Wolfram et al., Pricing Indirect Emissions Accelerates Low—Carbon Transition of US Light Vehicle Sector, 12 NATURE COMM’NS, (2021), https://doi.org/10.1038/s41467-021-27247-y.
EVs with the cleanest possible energy, the Environmental Protection Agency’s Energy Star program helps drivers determine which chargers rely on renewable energy sources.415

False Claim #31: Electric vehicles will cost the United States many automobile industry jobs.

"By most estimates under Biden’s electric vehicle mandate, 40 percent of all U.S. auto jobs will disappear—think of this—in one or two years."416

EV manufacturing need not result in fewer jobs in the U.S. automobile industry.417 A 2022 study found that manufacturing battery EV (BEV) powertrain components is more labor intensive than manufacturing powertrain components for internal combustion engine vehicles (ICEVs), which suggests that vehicle electrification may lead to powertrain manufacturing job growth.418 In addition, an Economic Policy Institute report concluded that “if the shift to BEVs is accompanied by strategic investments in manufacturing and job quality in the U.S. auto sector, then the number and quality of jobs can rise together with BEV production.”419

Electric vehicle production already has created thousands of new jobs in the United States. From 2015 to 2023, there were over 179,000 announced U.S. jobs related to EVs and EV batteries.420 In 2021, the domestic EV industry employed roughly 106,000 workers, more than a 90% increase from 2016 (roughly 55,000 jobs).421 In 2021 alone, the number of domestic jobs in the EV industry grew by over 26%.422

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418 Turner Cotterman et al., The transition to electrified vehicles: Evaluating the labor demand of manufacturing conventional versus battery electric vehicle powertrains at 1 (June 4, 2022), https://ssrn.com/abstract=4128130.
419 Jim Barrett & Josh Bivens, The Stake for Workers in How Policymakers Manage the Coming Shift to All-Electric Vehicles, ECONOMIC POLICY INSTITUTE (Sept. 22, 2021), https://www.epi.org/publication/ev-policy-workers/. The study authors focused on vehicle powertrains, "the automotive system responsible for generating the kinetic power to move the vehicle forward," because the powertrain is the least similar aspect between EVs and ICEVs. Id. At 3.
Moreover, economic incentives from the 2022 Inflation Reduction Act have increased domestic production and strengthened domestic supply chains. The Inflation Reduction Act provides a customer rebate of up to $7,500 for EVs produced in the United States. The IRA includes additional provisions that mobilize domestic mining and mineral processing, as well as battery manufacturing, to further concentrate EV supply chains within the United States. This has spurred broadly distributed job growth, with roughly 84,800 new EV-related jobs and $92.3 billion in EV-related investments announced since the passage of the IRA. And in addition to benefitting U.S. jobs, EVs are anticipated to benefit U.S. consumers: a recent Gartner analysis suggests that, on average, next-generation EVs will be cheaper to produce than comparable internal-combustion engine vehicles by 2027.

**False Claim #32: Electric vehicles are impractical due to range restrictions.**

"Here’s the problem with an electric car: they don’t go far. Very simple."

The majority of EVs can travel roughly 200 miles on a single charge and some models can travel over 400 miles on a single charge. Although the median range of a gasoline vehicle (403 miles) is roughly twice that of an EV (234 miles), the range of a standard EV is more than enough to meet the daily needs of median U.S. households. A 2016 study found that the travel requirements of 87% of vehicle owners could be met by existing, affordable electric vehicles. The average range of electric vehicles has only increased since then, from roughly 145 miles in 2016 to roughly 217 miles in 2021. Because most EV drivers charge their vehicles overnight at their home, most of these drivers can go about their daily driving with no need to stop to recharge.

EV range is also benefiting from the build-out of charging infrastructure. The United States is rapidly building electric charging stations, roughly tripling those in operation, from approximately 53,000 in 2017 to approximately 144,000 in 2021.

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425 Env'tl Defense Fund, supra note 420, at 4-5.


429 Dep’t of Energy, supra note 428.

430 Electric Vehicle Myths, supra note 18.


432 Evolution of average range of electric vehicles by powertrain, 2010-2021, supra note 428.

2022. Using funds from the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act, the United States has pledged to build 500,000 charging stations by 2030. This is more than three times the current number of gas stations. In addition, the United States installed 6,300 fast chargers in 2022, bringing the national total to 28,000 fast chargers. On a global scale, by 2022 there were 2.7 million EV chargers in operation worldwide, with more than 900,000 installed in 2022 alone, a 55% increase from 2021.

**False Claim #33: Electric vehicles cannot function in hot or cold weather.**

"Temperature affects EVs in bad ways."

Extreme temperatures can decrease EV range, particularly extreme cold, but this issue is not unique to EVs. According to a 2019 American Automobile Association report, when compared to conditions of 75°F with the HVAC set to Off, a typical EV’s range decreased by 12% at 20°F, and by 4% at 95°F. When comparing conditions with the HVAC set to Auto, a temperature drop from 72°F to 20°F decreased a typical EV’s range by 41%, and a temperature rise from 72°F to 95°F decreased range by 17%. However, EV models are increasingly adopting heat pump technology in place of traditional electric resistance heating, which can minimize the electricity consumption associated with heating an electric vehicle in extreme cold.

Traditional gasoline-powered cars are likewise susceptible to extreme weather conditions. Fuel economy tests have also shown a decrease in mileage per gallon for conventional gasoline cars due to temperature drops, with mileage roughly 15% lower at 20°F than at 72°F. As with EVs, decreased fuel efficiency for conventional gasoline cars in extreme weather is

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438 Id.
441 Id.
partially attributable to increased reliance on HVAC systems. Both EVs and gasoline-powered cars are likewise susceptible to cold temperatures lowering tire pressure.

Data from a roadside assistance company in Norway suggests that, by certain metrics, electric vehicles may actually be more reliable than gasoline-powered cars in the cold: 23% of vehicles in Norway are EVs, but the company reported that only 13% of the cases of vehicles failing to turn on in the cold were EVs.

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446 Fred Lambert, Electric vehicles fail at a lower rate than gas cars in extreme cold, ELECTREK, Jan. 17, 2024, https://electrek.co/2024/01/17/electric-vehicles-fail-lower-rate-than-gas-cars-extreme-cold/. The relatively strong performance of EVs in cold weather in Norway may be influenced by the more frequent use of home charging, more extensive charging port distribution, and drivers that are more accustomed to managing EVs in the cold. See Emily Schmall & Jenny Gross, Electric Car Owners Confront a Harsh Foe: Cold Weather, N.Y. TIMES, Jan. 17, 2024 (updated Jan. 18, 2024), https://www.nytimes.com/2024/01/17/business/tesla-charging-chicago-cold-weather.html.