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

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Columbia Law School | COLUMBIA CLIMATE SCHOOL SABIN CENTER FOR CLIMATE CHANGE LAW

REBUTTING 33 FALSE CLAIMS ABOUT SOLAR, WIND, AND ELECTRIC VEHICLES



APRIL 2024

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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.¹ However, "misinformation" and coordinated "disinformation" have at times undermined support for renewable energy projects and electric vehicles.² 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.³

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 2023.⁴ 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.⁵ 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%.⁶

False claims about renewable energy and electric vehicles 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 renewable energy projects while ignoring the many well-established methods to minimize

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¹ Brian Kennedy, Cary Funk & Alec Tyson, *Majorities of Americans Prioritize Renewable Energy, Back Steps to Address Climate Change*, Pew Research Center, June 28, 2023, https://www.pewresearch.org/science/2023/06/28/majorities-of-americans-prioritize-renewable-energy-back-steps-to-address-climate-change/.

² See Misinformation and disinformation, Am. Psychological Assoc., https://www.apa.org/topics/journalism-facts/misinformation-disinformation (last visited March 25, 2024) (explaining the distinction between misinformation and disinformation); Anahi Ayala Iacucci, Using Social Media in Community-Based Protection at 230 (2021), https://www.unhcr.org/innovation/wp-content/uploads/2021/01/Using-Social-Media-in-CBP.pdf (same).

³ The authors recognize that similar misinformation persists regarding energy transmission infrastructure, the buildout of which is necessary to support the expansion of renewable energy generation and electric vehicle adoption, but transmission is outside the scope of this report. *See* Lu Nelsen, From the Ground Up: Addressing Key Community Concerns in Clean Energy Transmission at 10, 12, 15-16 (2013), https://perma.cc/ENA2-S3DW (archived Aug. 28, 2019); *See Queued Up . . . But in Need of Transmission*, Dep't of Energy, Apr. 2022 https://perma.cc/KWO9-2PEY (archived Jan. 21, 2025).

⁴ Monmouth University Poll, *Support for Wind Energy Plunges*, Monmouth University, Aug. 29, 2023, https://www.monmouth.edu/polling-institute/documents/monmouthpoll nj 082923.pdf/.

⁵ Tracey Tully & Winston Choi-Schagrin, *Why 23 Dead Whales Have Washed Up on the East Coast Since December*, N.Y. TIMES, Feb. 28, 2023, https://www.nytimes.com/2023/02/28/nyregion/east-coast-whale-deaths.html.

⁶ See Monmouth University Poll, supra note 4.

⁷ How Solar Affects YOU!, No to Solar, https://perma.cc/63GB-ZQ3B (archived Nov. 1, 2023).

or even eliminate those impacts⁸ ("[I]ndustrial-scale solar isn't right for rural-agricultural areas . . . [because] [t]he land (forest, farmland, vegetation, soil) is forever destroyed."). Some frame any departure from the status quo, such as the use of farmland for solar production, as categorically inconceivable ("Ask yourself, if several thousand acres of agricultural land is converted to industrial solar facilities, who will grow your food? Bill Gates? Mark Zuckerberg?"). Some rely on unsubstantiated theories of causation, such as speculation that whale deaths stem from noise related to wind farm surveys, despite the fact that marine biologists have found that the sounds during offshore wind surveying are similar "to the sound of a fan in a room." Some drill down with single-minded focus on the toxicity or carbon footprint of renewable energy infrastructure or its component parts, while declining to acknowledge that fossil fuel extraction, production, and distribution cause far greater environmental contamination, harm to human health, and climate instability.

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. One academic center that has studied these origins in more detail, Brown University's Climate and Development Lab, has extensively mapped out some of the connections among such groups in the context of opposition to offshore wind development.

This report instead examines the substance of various claims against solar, wind, and electric vehicle deployment, focusing only on those claims that the authors have determined to be unfounded. Critically, the purpose of this report is <u>not</u> to establish that solar, wind, or electrical vehicles can be deployed without any adverse impacts or that each and every argument against solar, wind, or electrical vehicle deployment is baseless. Indeed, the energy transition will inevitably have some adverse impacts, including some adverse environmental impacts. However, renewable energy and its offshoots can also significantly reduce climate threats and improve public health, while providing jobs for millions of Americans. Ultimately, as Michael Gerrard has written, the energy transition will inevitably involve "difficult tradeoffs," and it will require difficult sacrifices, "in order to avoid far worse impacts."

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⁸ See, etc., BILL PEDERSON & BROOKS LAMB, AGRIVOLTAICS: PRODUCING SOLAR ENERGY WHILE PROTECTING FARMLAND (2021), https://cbey.yale.edu/sites/default/files/2021-10/CBEY REPORTS AGRIVOLTAICS FINAL 0.pdf; BIODIVERSITY CONSULTANCY, MITIGATING BIODIVERSITY IMPACTS ASSOCIATED WITH SOLAR AND WIND ENERGY DEVELOPMENT (2021), https://portals.iucn.org/library/sites/library/files/documents/2021-004-En.pdf.

⁹ 10 Reasons Industrial-Scale Solar Isn't Right for Agricultural-Rural Areas, Citizens for Responsible Solar, https://perma.cc/PYC8-SRPJ (archived Mar. 25, 2024).

¹⁰ Welcome to No Solar in Logan County (Ohio), No Solar in Logan County (Ohio), https://perma.cc/P45M-W5NF (archived Nov. 1, 2023).

¹¹ Pearl Marvell, *Wind Opponents Spread Myth about Dead Whales*, YALE CLIMATE CONNECTIONS, Sept. 19, 2023, https://yaleclimateconnections.org/2023/09/wind-opponents-spread-myth-about-dead-whales/.

¹² No to Solar, *supra* note 7.

¹³ See Hannah Ritchie, What are the safest and cleanest sources of energy?, Our World in Data, Feb. 10, 2020, https://ourworldindata.org/safest-sources-of-energy.

¹⁴ David Gelles, *The Texas Group Waging a National Crusade Against Climate Action*, N.Y. TIMES, Dec. 4, 2022, https://www.nytimes.com/2022/12/04/climate/texas-public-policy-foundation-climate-change.html; Marvell, *supra* note 11.

¹⁵ ISAAC SLEVIN ET AL., CLIMATE AND DEVELOPMENT LAB, AGAINST THE WIND: A MAP OF THE ANTI-OFFSHORE WIND NETWORK IN THE EASTERN UNITED STATES (2023), https://www.climatedevlab.brown.edu/post/against-the-wind-a-map-of-the-anti-offshore-wind-network-in-the-eastern-united-states.

¹⁶ Michael B. Gerrard, A Time For Triage, 39(6) ENVTL. F. 38 (November/December 2022), https://scholarship.law.columbia.edu/faculty-scholarship/3867.

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 misconceptions that do not fit into any of these categories.¹⁷ 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.¹⁸ The authors then developed 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, as well as Karen Florini and Emma Stieglitz for helping to facilitate technical review and Amory Lovins for providing technical feedback. 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." 19
- RMI's Reality Check: The IEA Busts 10 Myths about the Energy Transition.²⁰
- USA Today's Do wind turbines kill birds? Are solar panels toxic? The truth behind green-energy debates.²¹
- Carbon Brief's factchecks on electric vehicles and renewable energy, including: *Factcheck: How electric vehicles help to tackle climate change*, ²² *Factcheck: 21 misleading myths about electric vehicles*, ²³ and *Factcheck: Is solar power a 'threat' to UK farmland*?. ²⁴

¹⁷ 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.

¹⁸ See, e.g., No to Solar, supra note 7; No Solar in Logan County (Ohio), supra note 10; Defiance County Citizens for Responsible Solar, https://www.defiancecountycitizensforresponsiblesolar.com/ (last visited March 25, 2024); Windmills Kill, https://windmillskill.com/ (last visited March 25, 2024); Solar, Alliance for Wise Energy Decisions, https://wiseenergy.org/solar/ (last visited March 25, 2024); Letters: America Decides to Make Its Electrical Grid Dysfunctional, Wall Street Journal, June 12, 2022, https://www.wsj.com/articles/electric-grid-energy-green-blackout-generator-renewable-solar-wind-11654900508. See also, e.g., Julia Simon, Misinformation is derailing renewable energy projects across the United States, NPR, Mar. 28, 2022,

https://www.npr.org/2022/03/28/1086790531/renewable-energy-projects-wind-energy-solar-energy-climate-change-misinformation.

¹⁹ Electric Vehicle Myths, Envt'l Protection Agency, https://perma.cc/CBX5-2WG7 (last updated Jan. 21, 2025).

²⁰ Kingsmill Bond & Sam Butler-Sloss, *Reality Check: The IEA Busts 10 Myths about the Energy Transition*, RMI, Sept. 29, 2023, https://rmi.org/reality-check-the-iea-busts-10-myths-about-the-energy-transition/.

²¹ Elizabeth Weise, *Do wind turbines kill birds, Are solar panels toxic? The truth behind green-energy debates*, USA TODAY, Feb. 4, 2024 (updated Feb. 6, 2024),

https://www.usatoday.com/story/news/investigations/2024/02/04/green-energy-fact-checked/72390472007/.

²² Zeke Hausfather, *Factcheck: How electric vehicles help to tackle climate change*. ²², CARBONBRIEF, May 13, 2019, https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change/.

²³ Simon Evans, *Factcheck: 21 misleading myths about electric vehicles*, CarbonBrief, Oct. 24, 2023, https://www.carbonbrief.org/factcheck-21-misleading-myths-about-electric-vehicles/.

²⁴ Josh Gabbatis et al., *Factcheck: Is solar power a 'threat' to UK farmland?*, CARBONBRIEF, Aug. 25, 2022, https://www.carbonbrief.org/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*.²⁵
- The Annenberg Public Policy Center's website FactCheck.org, which includes factchecks on climate change related topics,²⁶ including electric vehicles.²⁷
- The Brown Climate and Development Lab's *Discourses of Climate Delay in the Campaign Against Offshore Wind: A Case Study from Rhode Island.*²⁸
- Emily Atkin's A guide to electric car misinformation.²⁹

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

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²⁵ Michael Freeman, *The Truth About Offshore Wind: Busting Oil Money Myths and Misinformation*, Center for American Progress, June 6, 2023, https://www.americanprogress.org/article/the-truth-about-offshore-wind-busting-oil-money-myths-and-misinformation/.

²⁶ See Issues: climate change, FACTCHECK.ORG, https://www.factcheck.org/issue/climate-change/ (last visited March 25, 2024).

²⁷ See D'Angelo Gore et al., *Trump's Misleading Claims About Electric Vehicles and the Auto Industry*, FACTCHECK.ORG, Oct. 2, 2023, https://www.factcheck.org/2023/10/trumps-misleading-claims-about-electric-vehicles-and-the-auto-industry/; Catalina Jaramillo, *Electric Vehicles Contribute Fewer Emissions than Gasoline-Powered Cars Over Their Lifetimes*, FACTCHECK.ORG, Feb. 7, 2024, https://www.factcheck.org/2024/02/electric-vehicles-contribute-fewer-emissions-than-gasoline-powered-cars-over-their-lifetimes/.

²⁸ DISCOURSES OF CLIMATE DELAY IN THE CAMPAIGN AGAINST OFFSHORE WIND: A CASE STUDY FROM RHODE ISLAND, BROWN CLIMATE AND DEVELOPMENT LAB (April 2023), https://ecori.org/wp-

content/uploads/2023/04/delay and misinformation tactics in anti osw campaigns-ri case study 4-10-23.pdf. ²⁹ Emily Atkin, *A guide to electric car misinformation (part 1)*, HEATED, March 27, 2024, https://heated.world/p/aguide-to-electric-car-misinformation.

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

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." ³⁰

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."³¹

EMF exposure levels vary according to the EMF source, proximity to the source, and duration of the exposure.³² 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).³³ 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)."³⁴ 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.³⁵

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."³⁶ 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."³⁷

³⁰ No to Solar, supra note 7.

³¹ Tommy Cleveland, *Health and Safety Impacts of Solar Photovoltaics*, NC STATE UNIVERSITY, 14 (May 2017), https://nccleantech.ncsu.edu/wp-content/uploads/2019/10/Health-and-Safety-Impacts-of-Solar-Photovoltaics-PV.pdf.

³² *Id.* at 15.

³³ *Id.*; Massachusetts Department of Energy Resources et al., *Questions & Answers: Ground-Mounted Solar Photovoltaic Systems*, 10-11 (Jun. 2015), http://www.mass.gov/eea/docs/doer/renewables/solar-pv-guide.pdf.

³⁴ Tommy Cleveland, supra note 31 at 15.

³⁵ *Id.*; Massachusetts Clean Energy Center, *Study of Acoustic and EMF Levels from Solar Photovoltaic Projects* (Dec. 2012), https://files.masscec.com/research/StudyAcousticEMFLevelsSolarPhotovoltaicProjects.pdf.

³⁶ Tommy Cleveland, *supra* note 31, at 16.

³⁷ *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."

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Roughly 40% of new solar panels in the United States and 5% of new solar panels in the world contain cadmium,³⁹ but this cadmium is in the form of cadmium telluride, which is non-volatile, non-soluble in water, and has 1/100th the toxicity of free cadmium.⁴⁰ Most solar panels, like many electronics, contain small amounts of lead.⁴¹ 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."⁴² 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."⁴³

All materials in a solar panel are "insoluble and non-volatile at ambient conditions," and "don't mix with water or vaporize into air."⁴⁴ 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.⁴⁵ 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."⁴⁶ 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."⁴⁷ 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."⁴⁸

³⁸ Emily Chantiri, *The Dark Side of Renewable Technology: Fossil Fuels Are Used to Produce Solar Panels*, Australian Computer Society (Feb. 2, 2023), https://ia.acs.org.au/article/2023/the-dark-side-of-renewable-technology.html.

³⁹ Polycrystalline Thin-Film Research: Cadmium Telluride, Nat'l Renewable Energy Laboratory, May 2022, https://www.nrel.gov/docs/fy21osti/76975.pdf; Taking Cadmium Telluride Technology to the Next Level, US-MAC, https://www.usa-cdte.org/ (last visited March 25, 2024).

⁴⁰ Health and Safety Impacts of Solar Photovoltaics at 7, NC CLEAN ENERGY TECHNOLOGY CENTER, May 2017, https://content.ces.ncsu.edu/health-and-safety-impacts-of-solar-photovoltaics.

⁴¹ Mark Hutchins, *The weekend read: A lead-free future for solar PV*, PV Magazine, Oct. 26, 2019, https://www.pv-magazine.com/2019/10/26/the-weekend-read-a-lead-free-future-for-solar-pv/.

⁴² Massachusetts Department of Energy Resources et al., *supra* note 33 at 5.

⁴³ *Id.*

⁴⁴ *Id.*

⁴⁵ *Id.*

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⁴⁷ NC CLEAN ENERGY TECHNOLOGY CENTER, *supra* note 40 at 7.

⁴⁸ Yasunari Matsuno, *Environmental risk assessment of CdTe PV systems to be considered under catastrophic events in Japan*, FIRST SOLAR, Dec. 1, 2013, https://www.firstsolar.com/-/media/First-Solar/Sustainability-Documents/Sustainability-Peer-Reviews/Japan_Peer-Reviews/J

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.⁴⁹ 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.⁵⁰ 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."⁵¹

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.⁵² In addition, the study noted that even the highest selenium concentrations observed were below the EPA's risk threshold for mammals.⁵³ 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.⁵⁴

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

"Solar panels pose a huge risk for overfilling the landfills."55

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." ⁵⁶

⁴⁹ 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.

⁵⁰ *Id.* at 21-22.

⁵¹ *Id.*; U.S. Environmental Protection Agency, *Ecological Soil Screening Level* (2018), https://perma.cc/93UQ-68PQ (last updated April 25, 2024).

⁵² Robinson et al., *supra* note 49, at 21-22.

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ No to Solar, *supra* note 7.

⁵⁶ 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.

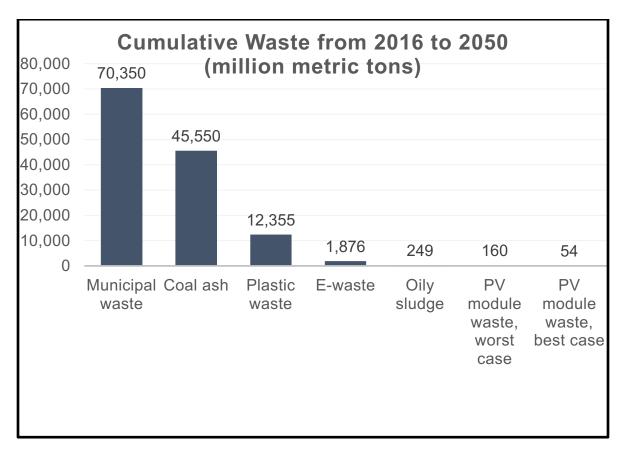


Figure 1: PV module waste from 2016-2050 compared to other sources of waste.

Source: The Sabin Center for Climate Change Law (visualizing data from Heather Mirletz et al.).⁵⁷

In addition, although only about 10% to 15% of solar panels are recycled in the United States,⁵⁸ 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.⁵⁹ 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."

⁵⁷ *Id.*

⁵⁸ Allyson Chu, *Scientists found a solution to recycle solar panels in your kitchen*, Wash. Post (Jul. 5, 2023), https://www.washingtonpost.com/climate-solutions/2023/07/05/solar-panel-recycling-microwave-technology/#.

⁵⁹ Solar Recycling Research & Development, Office of Energy Efficiency & Renewable Energy, Dep't of Energy, https://perma.cc/9HCF-SE5L (last visited Jan. 21, 2025).

⁶⁰ Zita Ngagoum Ndalloka et al., *Solar photovoltaic recycling strategies*, 270 Solar Energy 112379 (March 2024), at 9-10, https://www.sciencedirect.com/science/article/pii/S0038092X24000732.

Already, some companies have been able to recover 90% of solar panels' mass in their recycling processes.⁶¹ One commercial recycling plant in France can recycle more than 95% of a solar module.⁶² Bulk materials such as glass, steel, and aluminum are recoverable through existing recycling lines,⁶³ while certain semiconductor materials (tellurium and cadmium) can also be recovered at very high rates of 95% to 97%.⁶⁴ 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.⁶⁵ In addition, new companies are emerging with innovative technologies to recycle solar panels.⁶⁶

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." 67

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).⁶⁸ The emissions intensity of solar PV, meanwhile, is about 95 pounds per MWh, a difference of 976 pounds per MWh compared to natural gas.⁶⁹ According to a 2022 *Journal of Photovoltaics* study, utility-scale solar power produces between 394 and 447 MWh per acre per year.⁷⁰ 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.

https://perma.cc/BQ23-EDVB. NREL calculates emissions intensity using grams of carbon dioxide equivalent per kilowatt-hour.

69 Id.

⁶¹ M.M. Aman, et al., *A review of Safety, Health and Environmental (SHE) issues of solar energy system,* 41 Renewable and Sustainable Energy Reviews 1190 (2015), https://doi.org/10.1016/j.rser.2014.08.086.

⁶² Rong Deng et al., *Recent progress in silicon photovoltaic module recycling processes*, 187 Resources, Conservation and Recycling 106612 (2022), at 10, https://www.sciencedirect.com/science/article/pii/S0921344922004463.

⁶³ Garvin A. Heath, *Research and Development Priorities for Silicon Photovoltaic Module Recycling to Support a Circular Economy*, 5 NATURE ENERGY 502, 503 (2020), https://doi.org/10.1038/s41560-020-0645-2; U.S. Dep't of Energy, Office of Energy Efficiency & Renewable Energy, Solar Energy Technologies Office, Photovoltaics End-of-Life Action Plan 11 (2022), https://perma.cc/f5WA-CQDM.

⁶⁴ Md. Shahariar Chowdhury et al., *An overview of solar photovoltaic panels' end-of-life material recycling*, 27 Energy Strat. Reviews 100431, 100437 (2020), https://doi.org/10.1016/j.esr.2019.100431.

⁶⁵ Jon Hurdle, *As Millions of Solar Panels Age Out, Recyclers Hope to Cash In*, Yale Env't. 360 (Feb. 28, 2023), https://e360.yale.edu/features/solar-energy-panels-recycling.

⁶⁶ *Id.*

⁶⁷ 5 Things You Need to Know About Solar, CITIZENS FOR RESPONSIBLE SOLAR, https://perma.cc/VE5H-U33V (last visited March 25, 2024).

⁶⁸ Nat'l Renewable Energy Laboratory, Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update (Sept. 2021) (Table 1),

⁷⁰ Mark Bolinger and Greta Bolinger, *Land Requirements for Utility-Scale PV: An Empirical Update on Power and Energy Density*, 12 IEEE J. Voltaics 589, 593 (2022), https://www.doi.org/10.1109/JPHOTOV.2021.3136805.

By comparison, according to the EPA, an average acre of U.S. forest sequesters 0.857 metric tons of carbon dioxide per year.⁷¹ 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.⁷² Even assuming that all 83 metric tons of carbon (comprising 304 metric tons of carbon dioxide)⁷³ 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.⁷⁴ 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.⁷⁵

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."

There is overwhelming evidence that the lifecycle emissions⁷⁷ of solar energy are far lower than those of all fossil fuel sources, including natural gas.⁷⁸ On average, it takes only three years after installation for a solar panel to offset emissions from its production and transportation.⁷⁹ 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.⁸⁰

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

⁷¹ Greenhouse Gas Equivalencies Calculator – Revision History, U.S. Env't Prot. Agency, https://perma.cc/L7SC-TYVR (archived Jan. 21, 2025).

⁷² Greenhouse Gas Equivalencies Calculator – Calculations and References, U.S. Env'T PROT. AGENCY, https://perma.cc/4NZW-KXJD (archived Jan. 21, 2025).

⁷³ 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). *Id.*

⁷⁴ 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.

⁷⁵ 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. *Id.* This represents roughly 4% of the total capacity.

⁷⁶ No To Solar, *supra* note 7.

⁷⁷ 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 68, at 1.

⁷⁸ See generally id. at 3; Steffen Schlömer et al., 2014: Annex III: Technology-specific Cost and Performance Parameters, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 1329, 1335 (2014), https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf; Carbon Footprint of Solar Panel Manufacturing, Cool Effect (June 1, 2021), https://www.cooleffect.org/solar-carbon-footprint.
https://www.cooleffect.org/solar-carbon-foot

⁸⁰ What Is End-of-Life Management for Photovoltaics?, U.S. Dep't of Energy Solar Energy Tech. Office, https://perma.cc/4YRV-D4S6 (archived Jan. 21, 2025).

battery, pumped storage hydropower, and hydrogen storage technologies."⁸¹ The report found widespread agreement that all modes of solar power have total lifecycle emissions significantly below those of all fossil fuels.⁸² 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 CO₂-eq/KWh (carbon dioxide-equivalents per kilowatt-hour), respectively.⁸³ Coal, by contrast, generated lifecycle emissions of 1,001 grams of CO₂-eq/KWh, and natural gas generated lifecycle emissions of 486 grams of CO₂-eq/KWh.⁸⁴

Table 1. Median Published Life Cycle Emissions Factors for Electricity
Generation Technologies, by Life Cycle Phase

	Generation Technology	One-Time Upstream	Ongoing Combustion	Ongoing Non Combustion	One-Time Downstream	Total Life Cycle	Sources
Renewable	Biomass	NR	_	NR	NR	52	EPRI 2013 Renewable Electricity Futures Study 2012
	Photovoltaic ^a	~28	_	~10	~5	43	Kim et al. 2012 Hsu et al. 2012 NREL 2012
	Concentrating Solar Power ^b	20	_	10	0.53	28	Burkhardt et al. 2012
	Geothermal	15	_	6.9	0.12	37	Eberle et al. 2017
	Hydropower	6.2	_	1.9	0.004	21	DOE 2016
	Ocean	NR	_	NR	NR	8	IPCC 2011
	Wind ^c	12	_	0.74	0.34	13	DOE 2015
Storage	Pumped- storage hydropower	3.0	_	1.8	0.07	7.4	DOE 2016
	Lithium-ion battery	32	_	NR	3.4	33	Nicholson et al. 2021
	Hydrogen fuel cell	27	_	2.5	1.9	38	Khan et al. 2005
ewable	Nuclear ^d	2.0	_	12	0.7	13	Warner and Heath 2012
	Natural gas	0.8	389	71	0.02	486	O' Donoughue et al. 2013
	Oil	NR	NR	NR	NR	840	IPCC 2011
N N	Coal	<5	1010	10	<5	1001	Whitaker et al. 2012

Figure 2: Total lifecycle emissions for different energy sources.

Source: NREL.85

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

⁸¹ See Nat'l Renewable Energy Laboratory, supra note 68, at 1.

⁸² *Id.* at 1-3.

⁸³ See Schlömer, supra note 78, at 1335.

⁸⁴ *Id*

⁸⁵ Nat'l Renewable Energy Laboratory, *supra* note 68, at 3.

most efficient fossil fuel plants.⁸⁶ 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.

Technology	Anthropogenic heat emissions		
Solar PV- rooftop	-2.2		
Solar PV- utility	-2.2		
CSP	-2.2		
Wind-	-1.7 to -0.7		
onshore			
Wind-	-1.7 to -0.7		
offshore			
Geothermal	0		
Hydroelectric	0		
Wave	0		
Tidal	0		
Nuclear	1.6		
Biomass	3.4		
Natural gas-	0.61		
CCS/U			
Coal-CCS/U	1.5		

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

Source: M.Z. Jacobson⁸⁸

⁸⁶ Jaime Fernández Torres & Fontina Petrakopoulou, *A Closer Look at the Environmental Impact of Solar and Wind Energy*, GLOBAL CHALLENGES, June 22, 2022, https://onlinelibrary.wiley.com/doi/10.1002/gch2.202200016.

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⁸⁷ Mark Z. Jacobson, *Evaluation of Nuclear Power as a Proposed Solution to Global Warming, Air Pollution, and Energy Security,* Dec. 22, 2019, https://web.stanford.edu/group/efmh/jacobson/Articles/I/NuclearVsWWS.pdf.

⁸⁸ Id. Reproduced and adapted with permission.

Looking at academic scholarship from outside of the United States, 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 development is inherently harmful to biodiversity.

"Construction of an industrial-scale solar powerplant . . . creat[es] an ecological wasteland ."90

The impact of solar development on biodiversity depends on site-specific conditions, such as the local ecosystem, the existing land use, the density of development, and the management practices employed at the site. ⁹¹ When applying best practices for project design, including by incorporating pollinator habitat and minimizing soil disturbance, large-scale solar farms on previously developed land, including farmland, can sustain and even increase local biodiversity. ⁹² While developing solar projects on previously undeveloped land may contribute to habitat loss and degradation, as well as negative impacts to local biodiversity, these impacts can be mitigated by avoiding bulldozing and by creating wildlife corridors and habitat patches inside the footprint of the facility where soil and vegetation is not disturbed. ⁹³

Microclimates within solar farms can enhance botanical diversity, which, in turn can enhance the diversity of the site's invertebrate and bird populations. ⁹⁴ In addition, the shade under solar panels can offer critical habitat for a wide range of species, including endangered species. ⁹⁵ Shady patches likewise prevent soil moisture loss, boosting plant growth and diversity, particularly in areas impacted by climate extremes. ⁹⁶

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.⁹⁷ For example, developers can

⁹¹ See Parikhit Sinha et al., Best Practices in Responsible Land Use for Improving Biodiversity at a Utility-Scale Solar Facility, 2 CASE STUDIES IN THE ENV'T, 1, 1-2, 7-10 (2018), https://doi.org/10.1525/cse.2018.001123.

⁸⁹ Sudesh Nagu Kadam et. al, *Solar Panel Heat Emission and Its Environmental Impact*, 2 Int'L J. Advanced Rsch. Sci. Commc'n Tech. 3 (Dec. 2022), 113, 116, https://iiarsct.co.in/Paper13924.pdf.

⁹⁰ CITIZENS FOR RESPONSIBLE SOLAR, *supra* note 9.

⁹³ *Id.*; Steven M. Grodsky et al., *Solar energy development impacts flower-visiting beetles and flies in the Mojave Desert*, 263
BIOLOGICAL CONSERVATION 109336 (2021), https://www.sciencedirect.com/science/article/pii/S0006320721003888?via%3Dihub; Anna
Suuronen et al., *Influence of Solar Power Plants on Microclimatic Conditions and the Biotic Community in Chilean Desert Environments*, 60 ENVT'L MANAGEMENT 630 (2017), https://ink.springer.com/article/10.1007/s00267-017-0906-4; Hall Sawyer et al., *Trade-offs between utility-scale solar development and ungulates on western rangelands*, 20 FRONTIERS IN ECOLOGY AND THE ENV'T 345 (2022), https://esajournals.onlinelibrary.wiley.com/doi/10.1002/fee.2498.

⁹⁴ Parikhit Sinha et al., *supra* note 91 at 1-2.

⁹⁵ Hannah Montag et al., The effects of solar farms on local biodiversity at 34 (Apr. 2016), https://helapco.gr/wp-content/uploads/Solar Farms Biodiversity Study.pdf; Maggie Graham et al., *Partial shading by solar panels delays bloom, increases floral abundance during the late-season for pollinators in a dryland, agrivoltaic ecosystem*, 11 Sci. Rep. 7452, 7458, 7463 (2021), https://helapco.gr/wp-content/uploads/Solar Farms Biodiversity Study.pdf; Maggie Graham et al., *Partial shading by solar panels delays bloom, increases floral abundance during the late-season for pollinators in a dryland, agrivoltaic ecosystem*, 11 Sci. Rep. 7452, 7458, 7463 (2021), https://doi.org/10.1038/s41598-021-86756-4.

⁹⁶ 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.

⁹⁷ The Biodiversity Consultancy, *Mitigating biodiversity impacts associated with solar and wind energy development*, IUCN (2021), 12, https://portals.iucn.org/library/sites/library/files/documents/2021-004-En.pdf.

schedule construction to coincide with indigenous reptiles' and amphibians' hibernation periods, while avoiding breeding periods.⁹⁸

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. ⁹⁹ A recent study on the impact of newly-established insect habitat on solar farms in agricultural landscapes found increases in floral abundance, flowering plant species richness, insect group diversity, native bee abundance, and total insect abundance. ¹⁰⁰

Pollinators play a crucial role in U.S. farming, with more than one third of crop production reliant on pollinators.¹⁰¹ Bee populations alone contribute an estimated \$20 billion annually to U.S. agriculture production and up to \$217 billion worldwide.¹⁰² 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.¹⁰³

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?" 104

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 landuse scenario that DOE assessed in its 2021 *Solar Futures Study*.¹⁰⁵ 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 2021.¹⁰⁶ However, many of these projects will not be located on farmland.¹⁰⁷

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

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⁹⁸ *Id.* at 51.

⁹⁹ *Id.* at 54, 82.

¹⁰⁰ 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 Envt'l Research Letters 14053 (2024), at 1, https://iopscience.iop.org/article/10.1088/1748-9326/ad0f72.

¹⁰¹ Pollinator Habitat Planting: CP42, U.S. DEP'T AGRICULTURE, https://perma.cc/SE2Q-PWKX (archived Jan. 21, 2025).

¹⁰³ Buzzing Around Solar: Pollinator Habitat Under Solar Arrays, U.S. DEP'T ENERGY (Jun. 21, 2022), https://perma.cc/8DKD-EYCR (archived Jan. 21, 2025).

¹⁰⁴No Solar in Logan County (Ohio), *supra* note 10.

¹⁰⁵ U.S. Dep't. Energy Solar Energy Technologies Office, *Solar Futures Study*, U.S. Dep't. Energy Office of Energy Efficiency & Renewable Energy, at vi, 179 (Sep. 2021), https://perma.cc/TKM2-FLC7 (archived Feb. 25, 2025).

¹⁰⁶ U.S. Dep't. of Agriculture, Farms and Land in Farms: 2021 Summary, 4 (Feb. 2022), https://perma.cc/PW8B-QJLJ (archived Feb. 25, 2025).

¹⁰⁷ Eric Larson et al., *Net-Zero American: Potential Pathways, Infrastructure, and Impacts: Final Report*, Princeton University, 247 (Oct. 29, 2021), https://netzeroamerica.princeton.edu/the-report.

climates. 108 Agrivoltaics allow farmers to grow crops and even to graze livestock such as sheep beneath or between rows of solar panels.¹⁰⁹ When mounted above crops and vegetation, solar panels can provide beneficial shade during the day.¹¹⁰ Multiple studies have shown that these conditions can enhance a farm's productivity and efficiency. 111 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."112 Extra shading from solar panels also reduces evaporation, thereby reducing water usage for crops by around 14-29%, depending on the level of shade. 113 Reduced evaporation from solar installations can likewise mitigate soil erosion.¹¹⁴ Solar farms can also create refuge habitats for endangered pollinator species, further boosting crop yields while supporting native wild species. 115 Overall, agrivoltaics can increase the economic value of the average farm by over 30%, while increasing annual income by about 8%. 116 Farmers in other countries have begun implementing agrivoltaic systems. 117 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. 118

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.¹¹⁹ 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 powering electric vehicles to achieve the same number of transportation miles. 120 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.¹²¹ 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. 122 The figure below contrasts the land use

¹⁰⁸ National Renewable Energy Laboratory, Agrivoltaics, https://perma.cc/35Q7-ZRGS (archived Feb. 25, 2025).

¹⁰⁹ Michael Nuckols, Considerations when leasing agricultural lands to solar developers, Cornell Small Farms (Apr. 6, 2020), https://smallfarms.cornell.edu/2020/04/considerations-when-leasing-agricultural-lands-to-solar-developers/; Elnaz Adeh et al., Solar PV power potential is greatest over croplands, 9 Sci. Rep. 4 (2019), https://doi.org/10.1038/s41598-019-47803-3. ¹¹⁰ 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.

¹¹¹ Raúl Aroca-Delgado et al., Compatibility between Crops and Solar Panels: An Overview from Shading Systems, 10 Sustainability 743, 745 (2018), https://doi.org/10.3390/su10030743.

¹¹² 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.

¹¹³ Harashavardhan Dinesh & Joshua M. Pearce, The potential of agrivoltaic systems, 54 Renewable and Sustainable Energy Reviews 299, 302 (2016), https://doi.org/10.1016/j.rser.2015.10.024.

¹¹⁵ Empowering Biodiversity on Solar Farms, University of Georgia College of Agricultural and Environmental Sciences, 2020, https://www.caes.uqa.edu/research/impact/impact-statement/9839/empowering-biodiversity-on-solar-farms.html. ¹¹⁶ Dinesh & Pearce, supra note 113, at 305.

¹¹⁷ See, e.g., Makoto Tajima and Tetsunari Iida, Evolution of Agrivoltaic Farms in Japan, 2361 AIP CONF. PROC. 030002 (2021), https://doi.org/10.1063/5.0054674.

¹¹⁸ 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://perma.cc/D98R-NHH7 (archived Jan. 21, 2025).

¹¹⁹ Corn and Other Feed Grains - Feed Grains Sector at a Glance, U.S. DEP'T OF AGRICULTURE (last updated Jan. 5, 2025), https://perma.cc/RR6A-HZKY (archived Feb. 25, 2025).

¹²⁰ Paul Mathewson & Nicholas Bosch, Corn Ethanol vs. Solar: Land Use Comparison at 1 (Clean Wisconsin 2023), https://www.cleanwisconsin.org/wp-content/uploads/2023/01/Corn-Ethanol-Vs.-Solar-Analysis-V3-9-compressed.pdf. ¹²¹ *Id.*

¹²² *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. 123

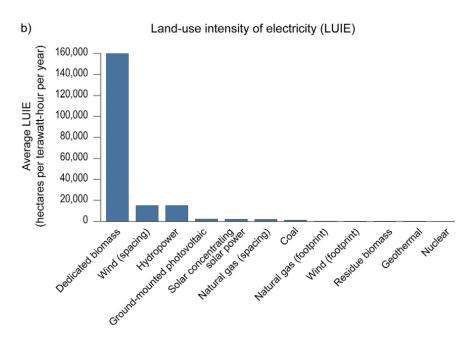


Figure 4: Average land-use intensity of electricity, measured in hectares per terawatt-hour per year.

Source: U.S. Global Change Research Program (visualizing data from Jessica Lovering et al.).¹²⁴

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.¹²⁵ 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 2050.¹²⁶ A 2019 IPCC report forecasted up

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¹²³ Jessica Lovering et al., *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.

¹²⁴ 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 123 at 8).

¹²⁵ Alisher Mirzabaev et al., *Severe climate change risks to food security and nutrition*, 39 Climate Risk Management 100473, 3 (2023), https://www.sciencedirect.com/science/article/pii/S2212096322000808 ("Adverse consequences are already occurring, and the chances of their exacerbation under climate change are high"); FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, CLIMATE CHANGE AND FOOD SECURITY: RISKS AND RESPONSES at ox-xii (2015), https://www.fao.org/3/i5188e/I5188E.pdf; *Agriculture and Climate*, U.S. ENV'T. PROT. AGENCY, https://perma.cc/A48A-DCQX (archived Jan. 21, 2025); Laura Reiley & Kadir van Lohuizen, *Climate change is pushing American farmers to confront what's next*, WASH. POST, Nov. 10, 2023,

https://www.washingtonpost.com/business/interactive/2023/american-agriculture-farming-climate-change/.

¹²⁶ IPCC, Climate Change 2022: Impacts, Adaptation, and Vulnerability (2022), 717, https://www.ipcc.ch/report/ar6/wq2/downloads/report/IPCC AR6 WGII FullReport.pdf.

to 29% price increases for cereal grains by 2050 due to climate change. 127 These price increases would strain consumers globally, while also producing uneven regional effects. 128 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. 129 For example, wheat grown at 546–586 parts per million (ppm) CO_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. 130 Distributions of pests and diseases will also change, harming agricultural production in many regions. 131 Such impacts will only intensify for as long as we continue to burn fossil fuels. 132

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." 133

Solar development creates significantly more jobs per unit of energy generated than other types of energy production, including natural gas.¹³⁴ 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.¹³⁵

¹³¹ *Id.*; Climate Change 2022: Impacts, Adaptation, and Vulnerability, *supra* note 126, at 718.

¹²⁷ Chiekh Mbow et al., Food Security, *in Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gases fluxes in terrestrial ecosystems,* Exec. Summary, Intergovernmental Panel on Climate Change, https://www.ipcc.ch/srccl/chapter/chapter-5/ (2019).

¹²⁸ Id.; see also Climate Change 2022: Impacts, Adaptation, and Vulnerability, supra note 126, at 796.

¹²⁹ Climate Change 2022: Impacts, Adaptation, and Vulnerability, *supra* note 126, at 717.

¹³⁰ Mbow et al., *supra* note 127.

¹³² Causes and Effects of Climate Change, UNITED NATIONS, https://www.un.org/en/climatechange/science/causes-effects-climate-change (last visited March 25, 2024).

Diana Furchtgott-Roth, *The Hypocrisy of the Left on Energy Policy*, Heritage Foundation (May 9, 2023), https://www.heritage.org/energy-economics/commentary/the-hypocrisy-the-left-energy-policy.

¹³⁴ National Association of State Energy Officials et al., *Wages, Benefits and Change*, https://www.usenergyjobs.org/s/Wage-Report.pdf (last visited March 25, 2024).

¹³⁵ U.S. GLOBAL CHANGE RESEARCH PROGRAM, supra note 124, at 32-31.

Energy Employment from 2020 to 2050 for Alternative Net-Zero Pathways

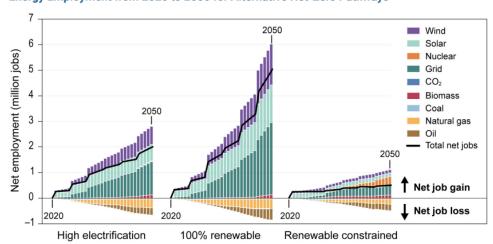


Figure 5: Energy employment from 2020 to 2050 under various U.S. net-zero GHG emissions scenarios.

Source: U.S. Global Change Research Program. 136

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.¹³⁷ 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.¹³⁸ 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.¹³⁹ 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.¹⁴⁰

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. ¹⁴¹ In response, manufacturers have announced plans to build multibillion dollar solar panel manufacturing facilities and related battery

¹³⁷ United States Energy & Employment Report 2023, U.S. DEP'T OF ENERGY (June 2023), https://perma.cc/M466-4GY5 (archived Feb. 25, 2025).

¹⁴⁰ United States Energy & Employment Report 2023, supra note 134 at 4.

¹³⁶ *Id.*

¹³⁸ National Solar Jobs Census 2022, Interstate Renewable Energy Council, https://irecusa.org/programs/solar-jobs-census/ (last visited March 25, 2024).

¹³⁹ Ryan Van Velzer, *Kentucky has the second fastest growing clean energy sector in the U.S.*, Louisville Public Media, Sept. 27, 2023, https://www.lpm.org/news/2023-09-27/kentucky-has-the-second-fastest-growing-clean-energy-sector-in-the-u-s.

DOE Optimizes Structure to Implement \$62 Billion in Clean Energy Investments From Bipartisan Infrastructure Law, U.S. Dep't. Energy (Feb. 9, 2022), https://perma.cc/6L27-GCCE (archived Jan. 21, 2025).

manufacturing facilities in the United States that will employ thousands of workers. ¹⁴² At a smaller scale, the emerging solar recycling industry has also begun to create jobs. ¹⁴³

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."¹⁴⁴

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).¹⁴⁵ In 2022, the United States manufactured approximately 10% more solar panels than in 2021.¹⁴⁶ This share is likely to grow as manufacturers take advantage of IIJA and IRA incentives to open factories in the United States.¹⁴⁷ 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.¹⁴⁸

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.¹⁴⁹ Tariffs

 ¹⁴² See, e.g., Syris Valentine, *The IRA has injected \$240 billion into clean energy. The US still needs more*, GRIST, Mar. 12, 2024, https://grist.org/economics/the-ira-has-injected-250-billion-into-clean-energy-it-might-not-be-enough/; Zack Budryk, *White House touts biggest single investment in US solar by Korean company,* The Hill (Jan. 11, 2023), https://thehill.com/policy/energy-environment/3807489-white-house-touts-biggest-single-investment-in-u-s-solar-energy-by-korean-company/; *Gov. Kemp: Battery Manufacturer to Invest \$2.57B*, *Create Over 700 Jobs in Coweta County,* Governor Brian P. Kemp Office of the Governor (Nov. 11, 2022), https://gov.georgia.gov/press-releases/2022-11-11/gov-kemp-battery-manufacturer-invest-257b-create-over-700-jobs-coweta.
 ¹⁴³ Jon Hurdle, *As Millions of Solar Panels Age Out, Recyclers Hope to Cash In*, Yale Environment 360 (February 28, 2023), https://e360.yale.edu/features/solar-energy-panels-recycling; *SOLARCYCLE Raises \$30M to Scale Advanced Recycling for the Solar Industry*, SolarCycle News (March 15, 2023), https://www.solarcycle.us/press-releases/solarcycle-raises-30m-equity-financing-to-scale-advanced-recycling-for-the-solar-industry.

¹⁴⁴ Kenneth Rapoza, *How China's Solar Industry Is Set Up to Be the New Green OPEC*, FORBES (Mar. 14, 2021), https://www.forbes.com/sites/kenrapoza/2021/03/14/how-chinas-solar-industry-is-set-up-to-be-the-new-green-opec/?sh=f3f6e851446d.

¹⁴⁵ U.S. solar photovoltaic module shipments up 33% in 2020, U.S. ENERGY INFORMATION ADMINISTRATION (Sep. 2, 2021), https://perma.cc/NQ5M-GAT9 (archived Jan. 21, 2025); U.S. Dep't. of Energy Solar Energy Tech. Office, Solar manufacturing, U.S. Dep't. of ENERGY OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, https://perma.cc/K7FH-MQFP (archived Jan. 21, 2025). ¹⁴⁶ David Feldman et al., Spring 2023 Solar Industry Update, Nat'l Renewable Energy Laboratory, 68 (Apr. 27, 2023), https://perma.cc/CR8U-DGYG (archived Jan. 21, 2025).

¹⁴⁷ U.S. Dep't. of Energy, *DOE Fact Sheet: The Bipartisan Infrastructure Deal Will Deliver For American Workers, Families and Usher in the Clean Energy Future*, U.S. Department of Energy (Nov. 9, 2021), https://perma.cc/8N4G-UJET (archived Feb. 25, 2025); Bella Isaacs-Thomas, *What the Inflation Reduction Act does for green energy*, PBS News Hour (Aug. 17, 2022), https://www.pbs.org/newshour/science/what-the-inflation-reduction-act-does-for-green-energy; U.S. Dep't of Energy, Inflation Reduction Act of 2022, https://perma.cc/FG4Z-6YBP (archived Jan. 21, 2025); Kavya Balaraman, *Inflation Reduction Act could spur American Manufacturing Renaissance*, *Advocates Say*, UTILITYDIVE (Aug. 18, 2022), https://www.utilitydive.com/news/inflation-reduction-act-solar-manufacturing-seia/630061/.

¹⁴⁸ Interstate Renewable Energy Council, *supra* note 138.

David Feldman et al., *supra* note 146, at 68, 80; Ian Tiseo, *Distribution of solar photovoltaic modules imported in the united States in 2022, by country of origin*, Statista, Jan. 25, 2024, https://www.statista.com/statistics/232941/us-imports-of-solar-equipment-by-source-contry/.

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%). 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. 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.

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 [sic1 values will increase." 153

Data across multiple studies show that utility-scale solar projects do not have major impacts on the values of surrounding properties.¹⁵⁴ 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.¹⁵⁵ 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.¹⁵⁶ Homes located more than 1 mile from a solar farm were found to experience no statistically significant effect on its price.¹⁵⁷ 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.¹⁵⁸ These declines were concentrated in suburban areas, where there is more competition for space.¹⁵⁹ In rural communities there was no impact on property values.¹⁶⁰ Other studies have also found that utility-scale solar farms have a greater impact on property values in areas with higher residential population density.¹⁶¹

¹⁵⁰ David Feldman et al., *supra* note 146, at 68, 80.

¹⁵¹ Eric McDaniel, *The U.S. Imports Most of Its Solar Panels. A New Ruling Might Make That More Expensive*, National Public Radio (Aug. 18, 2023), https://www.npr.org/2023/08/18/1194303196/solar-panel-imports-china%20and%20.

¹⁵² U.S. Department of Commerce, *Department of Commerce Issues Preliminary Determination of Circumvention Inquiries of Solar Cells and Modules Produced in China*, Dec. 2, 2022, https://perma.cc/RJP4-ZWRC (archived Jan. 21, 2025).

¹⁵³ Property Values, CITIZENS FOR RESPONSIBLE SOLAR, https://perma.cc/UWK6-35Z2 (archived Feb. 25, 2025).

¹⁵⁴ Richard Kirkland, *Grand Solar Impact Study*, KIRKLAND APPRAISALS, (Feb. 25, 2016), https://www.southripleysolar.com/wp-content/uploads/2020/09/Kirkland-Grandy-Solar-Impact-Study.pdf; *Solar and Property Value*, Solar Energy Industries Association (Jul. 2019), https://www.seia.org/sites/default/files/2019-09/Solar%20Property%20Value%20FactSheet%202019-PRINT 1.pdf.

 ¹⁵⁵ Salma Elmallah et al., Shedding Light on Large-Scale Solar Impacts: An Analysis of Property Values and Proximity to Photovoltaics Across Six U.S. States, 175 Energy Policy 113425 (2023), https://doi.org/10.1016/j.enpol.2023.113425.
 156 Id. at 113425.

¹⁵⁷ *Id*.

¹⁵⁸ Vasundhara Gaur et al., *Property Value Impacts of Commercial-Scale Solar Energy In Massachusetts And Rhode Island*, Dep't. Env't. AND NAT. Res. Econ. U. R.I., 4 (2020), https://www.uri.edu/news/wp-content/uploads/news/sites/16/2020/09/PropertyValueImpactsOfSolar.pdf.

¹⁵⁹ *Id.* at 35.

¹⁶⁰ *Id.* at 35.

¹⁶¹ Leila Al-Hamoodah et al., *An Exploration of Property-Value Impacts Near Utility-Scale Solar Installations*, Lawrence Berkeley National Laboratory (May 2018),

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."¹⁶² 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. ¹⁶³ 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. ¹⁶⁴

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. ¹⁶⁵ In that study, 92% of the power plants surveyed were fueled by natural gas. ¹⁶⁶

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!" 167

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." ¹⁶⁸

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 PV is \$60/MWh.¹⁶⁹ 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.¹⁷⁰ The figure below from Lazard shows historical mean unsubsidized LCOE values for different types of utility-scale energy generation.

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PATRICIA McGarr & Andrew Lines, Property Value Impact Study: Proposed Solar Farm, McLean County, IL, at 17, (Aug. 7, 2018), https://www.mcleancountyil.gov/DocumentCenter/View/13192/Patricia-L-McGarr—Property-Value-Impact-Study.
 Id.

¹⁶⁴ Leila Al-Hamoodah et al., *supra* note 161.

¹⁶⁵ Lucas Davis, *The Effect of Power Plants on Local Housing Value and Rents*, 93 Rev. Econ. Stat. 1391 (2011), https://doi.org/10.1162/rest a 00119.

¹⁶⁶ *Id.* at 1400.

 $^{^{167}}$ No to Solar, *supra* note 7.

¹⁶⁸ World Energy Outlook 2020, Int'l. Energy Agency, 202, 214 (2020), https://iea.blob.core.windows.net/assets/a72d8abf-de08-4385-8711-b8a062d6124a/WEO2020.pdf.

¹⁶⁹ Levelized Cost of Energy Analysis: Version 16.0, Lazard, 9 (Apr. 2023), https://www.lazard.com/media/2ozoovyg/lazards-lcoeplus-april-2023.pdf.

¹⁷⁰ *Id.*

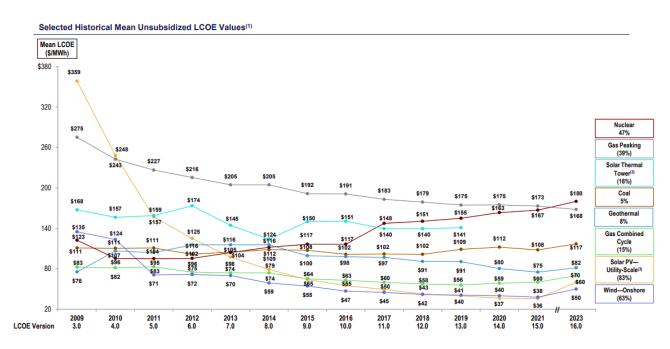


Figure 6: Selected historical mean unsubsidized LCOE values. This graph reflects the average of the high and low LCOE for each technology in each year. The percentages on the right of the figure represent the decrease in average LCOE since 2009. **Source: Lazard.**¹⁷¹

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.¹⁷² 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.¹⁷³ 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 2023.¹⁷⁴

¹⁷¹ *Id.* Reproduced with permission.

¹⁷² *Id*

¹⁷³ See U.S. GLOBAL CHANGE RESEARCH PROGRAM, supra note 124, at 32-15.

¹⁷⁴ Dan Gearino, *Inexpensive Solar Panels Are Essential for the Energy Transition. Here's What's Happening With Prices Right Now,* INSIDE CLIMATE News (Jun. 15, 2023), https://insideclimatenews.org/news/15062023/inside-clean-energy-solar-panel-prices-drop/.

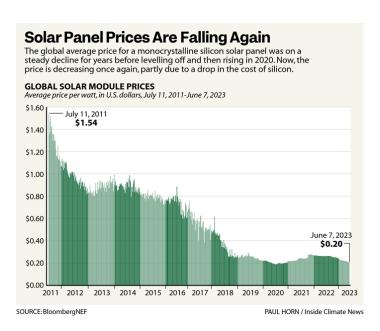


Figure 7: Solar price from 2011 to 2023. Source: BloombergNEF/Paul Horn/Inside Climate News. 175

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. 176 The figure below from ICF shows the anticipated impact of the IRA on the subsidized LCOE for solar.

¹⁷⁵ *Id.* Reproduced with permission.

¹⁷⁶ Ian Bowen et al., How clean energy economics can benefit from the biggest climate law in US history, ICF (Sept. 16, 2022), https://www.icf.com/insights/energy/clean-energy-economic-benefits-us-climate-law; see also Lazard, supra note 169, at 3.

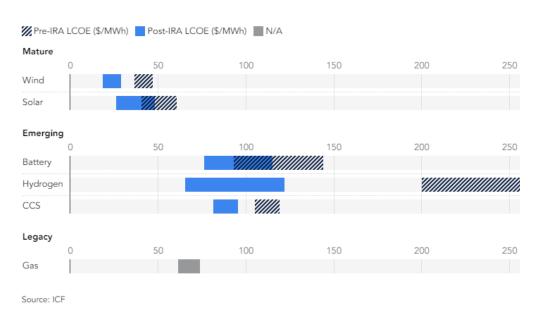


Figure 8: Impact of the IRA on anticipated LCOE in 2030.

Source: ICF.177

Fossil fuels also receive subsidies, albeit smaller subsidies than renewable energy currently received.¹⁷⁸ In fiscal year 2022, the federal government's tax expenditures for natural gas and petroleum subsidies were \$2.1 billion.¹⁷⁹

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. 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. States.

¹⁷⁷ *Id.* Reproduced with permission.

¹⁷⁸ Federal Financial Interventions and Subsidies in Energy in Fiscal Years 2016-2022, U.S. Energy Information Admin., at 3 (Aug. 2023), https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf.

¹⁷⁹ *Id*. at 3-4

¹⁸⁰ LAZARD, *supra* note 169, 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.* ¹⁸¹ *Id.*

Levelized Cost of Energy Comparison—Cost of Firming Intermittency

The incremental cost to firm⁽¹⁾ intermittent resources varies regionally, depending on the current effective load carrying capability ("ELCC")⁽²⁾ values and the current cost of adding new firming resources—carbon pricing, not considered below, would have an impact on this analysis LCOE v16.0 Levelized Firming Cost (\$/MWh)⁽³⁾

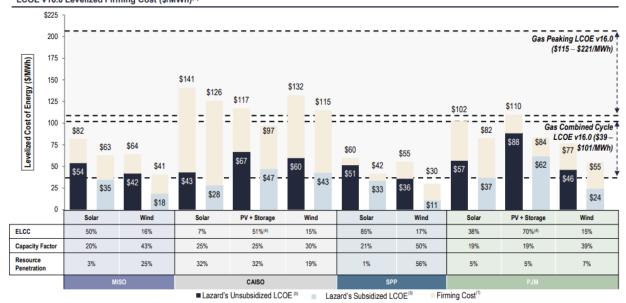


Figure 9: LCOE for wind, solar, and solar plus storage, adjusted for the cost of firming intermittency.

Source: Lazard. 182

False Claim #12: Solar panels don't work in cloudy or cold climates.

"A cloud goes over and solar plummets" 183

Solar panels generate energy even in cloudy or cold conditions.¹⁸⁴ Although cloudy weather may reduce power generation by more than 45%, substantial energy can still be generated during those conditions.¹⁸⁵

Furthermore, while the reduction in sunlight during the winter months significantly reduces solar generation, colder temperatures themselves generally do not reduce electricity output—and can actually increase solar panel efficiency by

¹⁸³ Brian Gitt, *Solar's Dirty Secrets: How Solar Power Hurts People and the Planet*, Atomic Insights (Feb. 24, 2022), https://atomicinsights.com/solars-dirty-secrets-how-solar-power-hurts-people-and-the-planet/. [See comment from Chris Morris, March 17, 2022 at 2:23 AM].

¹⁸² *Id.* Reproduced with permission.

¹⁸⁴ 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.

185 Ramli et al., supra note 184, at 843.

increasing voltage.¹⁸⁶ Crystalline silicon cells, which comprise approximately 84% of the U.S. market, and cadmium telluride cells, which comprise approximately 16% of the U.S. market, actually perform better in colder temperatures.¹⁸⁷ Only amorphous silicon cells, which represent a negligible percentage of the U.S market, experience decreased performance in colder temperatures.¹⁸⁸

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." 189

Complete reliance on solar generation, without other sources of power generation, energy storage, long-distance transmission, or other grid flexibility resources, ¹⁹⁰ would pose intermittency challenges. However, an increasing number of planned solar projects are set to include an energy storage component, ¹⁹¹ and solar, wind, and storage together can provide the majority of the country's electricity without compromising reliability. ¹⁹²

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.¹⁹³ As a result, increased reliance on solar energy need not require the construction of new natural gas plants for backup.¹⁹⁴ 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.¹⁹⁵ 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

23

¹⁸⁶ 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; George Makrides et al., *Temperature and thermal annealing effects on different photovoltaic technologies*, 43 Renewable Energy 407, 407-411 (2012), https://www.sciencedirect.com/science/article/pii/S0960148111006483.

¹⁸⁷ See Makrides et al., supra note 186, at 410-411; Solar Photovoltaics: Supply Chain Deep Dive Assessment, U.S. Dep't of Energy, Feb. 24, 2022, at iii, https://perma.cc/8XYH-TP72 (archived Feb. 25, 2025).

¹⁸⁸ See Makrides et al., supra note 186, at 407, 411; Solar Photovoltaics: Supply Chain Deep Dive Assessment, U.S. Dep't of Energy, supra note 187, at iii.

¹⁸⁹ Solar Energy Is Unreliable, CITIZENS FOR RESPONSIBLE SOLAR, https://perma.cc/C8MS-OEUE (archived Feb. 25, 2025).

¹⁹⁰Amory Lovins has identified eight "grid flexibility" resources that can substitute for bulk storage or fossil fuel backup: (1) efficient use, which reduces peak load; (2) flexible demand; (3) modern forecasting; (4) diversifying variable renewables; (5) integration with dispatchable alternatives and cogeneration; (6) distributed or managed thermal storage; (7) distributed electrical storage; and (8) hydrogen. Amory B. Lovins, *Reliably integrating variable renewables: Moving grid flexibility resources from models to results*, 30 ELECTRICITY J. 58, 58-61 (2017), https://www.sciencedirect.com/science/article/pii/S1040619017302889?via%3Dihub.

¹⁹¹ JOSEPH RAND ET AL., QUEUED UP: CHARACTERISTICS OF POWER PLANTS SEEKING TRANSMISSION INTERCONNECTION AS OF THE END OF 2021 at 13 (Berkely Lab 2022), https://eta-publications.lbl.gov/sites/default/files/queued_up_2021_04-13-2022.pdf.

¹⁹² See Eric Larson et al., supra note 107, 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).

¹⁹³ Robert Fares, *Renewable Energy Intermittency Explained: Challenges, Solutions, and Opportunities,* Scientific America (Mar. 11, 2015), https://blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/; Mark Jacobson, *Renewable Energy's Intermittency is Not a Showstopper*, Am. Physical Soc'y. (Apr. 20, 2022), https://physics.aps.org/articles/v15/54.

¹⁹⁴ The 2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Electricity Future, U. Cal. Berkeley Goldman Sch. Pub. Pol'y, 4 (2020), https://cta-redirect.hubspot.com/cta/redirect/6000718/8a85e9ea-4ed3-4ec0-b4c6-906934306ddb.

¹⁹⁵ U.S. Dep't. Energy Solar Energy Technologies Office, Solar Futures Study, supra note 105, at 215.

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 2049/2050.¹⁹⁶ 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 2035/2036 and to between 40.1% and 44.8% by 2049/2050. 197 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. 198 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. 199

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%.²⁰⁰ By 2022, solar had increased to 19.9% of California's in-state electricity generation, while natural gas had decreased to 47.5%.²⁰¹ Significantly, even with this increase in solar reliance, California's grid reliability remains near, or above, the national average.²⁰² 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.²⁰³ 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.²⁰⁴

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.²⁰⁵ 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

¹⁹⁶ *Id.*

¹⁹⁷ *Id.*

¹⁹⁸ Larson et al., *supra* note 107, at 88, 261.

¹⁹⁹ *Id.* at 261.

²⁰⁰ California Energy Comm'n., *Electric Generation Capacity and Energy*, https://www.energy.ca.gov/data-reports/energy- almanac/california-electricity-data/electric-generation-capacity-and-energy (last visited March 25, 2024).

²⁰¹ California Energy Comm'n, 2022 Total System Electric Generation, https://www.energy.ca.gov/data-reports/energyalmanac/california-electricity-data/2022-total-system-electric-generation (last visited March 25, 2024).

²⁰² California Public Utilities Comm'n, Electric System Reliability Annual Reports, https://www.cpuc.ca.gov/industries-andtopics/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.

²⁰³ See E&E News & Benjamin Storrow, Solar Power Bails Out Texas Grid During Major Heat Wave, Scientific American, June 26, 2023, https://www.scientificamerican.com/article/solar-power-bails-out-texas-grid-during-major-heat-wave/.

²⁰⁴ Joshua W. Busby et al., *Cascading risks: Understanding the 2021 winter blackout in Texas*, 77 Energy Research and Social Science 102106, 1-4 (2021), https://www.sciencedirect.com/science/article/pii/S2214629621001997; Adriana Usero & Salvador Rizzo, 'Frozen windmills' aren't to blame for Texas's power failure, WASH, POST, Feb. 18, 2021,

https://www.washingtonpost.com/politics/2021/02/18/frozen-windmills-arent-blame-texass-power-failure-neither-is-green-new-deal/; Dionne Searcey, No, Wind Farms Aren't the Main Cause of the Texas Blackouts, N.Y. TIMES, Feb. 17, 2021 (updated May 3, 2021), https://www.nytimes.com/2021/02/17/climate/texas-blackouts-disinformation.html.

²⁰⁵ U.S. Dep't. Energy Solar Energy Technologies Office, *Solar Futures Study, supra* note 105 at 33.

and less expensive material.²⁰⁶ Researchers are likewise developing more efficient utility-scale methods for storing solar energy.²⁰⁷

Other researchers have highlighted energy efficiency and grid flexibility mechanisms that can complement and support solar and wind without the need for fossil fuel backup or even bulk, utility-scale energy storage.²⁰⁸ These include integrative design practices to significantly reduce the energy demands of buildings and other sectors; demand flexibility and demand response mechanisms to compensate customers for reduced energy use during peak hours; and distributed thermal and electrical storage.²⁰⁹

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.²¹⁰ A National Renewable Energy Laboratory (NREL) study found that the median failure rate for panels installed between 2000 to 2015 was five out of 10,000 annually, a rate of 0.05%.²¹¹ 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.²¹²

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."²¹³

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.²¹⁴ According to that study, production rates for

²⁰⁶ Karyn Hede, *Longer Lasting Sodium-Ion Batteries on the Horizon,* Pac. Nw. Nat'l. Lab'y. (Jul. 13, 2022), https://perma.cc/7G6K-5ENQ (archived Feb. 25, 2025).

²⁰⁷ Robert Armstrong et al., *The Future of Energy Storage: An Interdisciplinary MIT Study, Mass. Inst. Tech.* (Jun. 3, 2022), https://energy.mit.edu/wp-content/uploads/2022/05/The-Future-of-Energy-Storage.pdf.

²⁰⁸ Amory B. Lovins, *Reliably integrating variable renewables: Moving grid flexibility resources from models to results, supra* note 190, at 58-61.

²⁰⁹ *Id.*; Amory B. Lovins, *How big is the energy efficiency resource?*, 13 Envr'l R. Letters at 1-14 (2018), https://iopscience.iop.org/article/10.1088/1748-9326/aad965; Amory B. Lovins & M. V. Ramana, *Three Myths About Renewable Energy and the Grid, Debunked*, Yale Env't 360, Dec. 9, 2021, https://e360.yale.edu/features/three-myths-about-renewable-energy-and-the-grid-debunked.

²¹⁰ Dirk C. Jordan et al., *Photovoltaic failure and degradation modes*, 25 Photovoltaics Res. and Applications 318, 324 (2017), https://doi.org/10.1002/pip.2866; Dirk C. Jordan et al., *PV field reliability status—Analysis of 100 000 solar systems*, 28 Photovoltaics Research and Applications 739, 747 (2020), https://doi.org/10.1002/pip.3262.

²¹¹ Jordan et al., *Photovoltaic failure and degradation modes, supra* note 210, at 324 (2017).

²¹² Emiliano Bellini, *Survey shows 34.3% failure rate for residential inverters over 15 years*, PV Magazine, Feb. 8, 2023, https://www.pv-magazine.com/2023/02/08/survey-shows-34-3-failure-rate-for-residential-inverters-over-15-years/ (discussing Christof Bucher et al., Life Expectancy of PV Inverters and Optimizers in Residential PV Systems, BERN UNIVERSITY OF APPLIED SCIENCES, 2022, https://www.bfh.ch/dam/jcr:5bfd5c32-f70f-4bf6-8d60-fdab6094e164/2022 09 WCPEC-8 3DV.1.46 -

Life Expectancy of PV inverters.pdf).

Not Enough Rare Metals to Scale Up Solar Power, ENERGYSKEPTIC.COM (Feb. 21, 2021), https://energyskeptic.com/2021/solar-pv-cells-using-rare-elements-unlikely-to-scale-up-enough-to-replace-fossil-fuels/.

Seaver Wang et al., Future demand for electricity generation materials under different climate mitigation scenarios, 7 JOULE 309, 315 (Feb. 2023), https://www.cell.com/joule/pdfExtended/S2542-4351(23)00001-6; see also Seth Borenstein, Study: Enough rare earth

many critical materials will need to grow substantially, but "[g]lobal mineral reserves should adequately meet needs posed by power sector material demand."²¹⁵ 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."²¹⁶ Other analyses suggest that global mineral resources are likely sufficient to meet long-term demand across all energy transition sectors, including EVs and transmission.²¹⁷

In addition, as noted previously, innovations in recycling solar panels²¹⁸ can potentially reduce future requirements for individual raw materials.²¹⁹ 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.²²⁰ 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.²²¹ 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 1872.²²² These recommendations include substantial research investments, permitting reform, and proactive public and

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minerals to fuel green shift, Associated Press, Jan. 27, 2023, https://apnews.com/article/science-green-technology-climate-and-environment-renewable-energy-141761657a8e7a5627a0e49e601dd48e.

²¹⁵ Wang et al., *Future demand for electricity generation materials under different climate mitigation scenarios, supra* note 214, at 320. ²¹⁶ *Byproduct Mineral Commodities Used for the Production of Photovoltaic Cells*, US GEOLOGIC SURVEY (2010), 2, https://pubs.usgs.gov/circ/1365/Circ1365.pdf.

MATERIAL AND RESOURCE REQUIREMENTS FOR THE ENERGY TRANSITION, ENERGY TRANSITIONS COMMISSION (2023), https://www.energy-transitions.org/wp-content/uploads/2023/08/ETC-Materials-Report highres-1.pdf; Hannah Ritchie, We have enough minerals for the energy transition, but medium-term supply is a challenge [Part 1], Sustainability by Numbers, Dec. 1, 2023,

https://www.sustainabilitybynumbers.com/p/transition-mineral-demand-part-one. At least one researcher, Simon P. Michaux, has concluded the opposite, but his analysis generally focuses on currently known global reserves—deposits that can be economically mined or extracted with current technologies—rather than the broader category of global resources, and his analysis does not give the same weight as the Energy Transitions Commission's to potential reductions in material demand through advances in efficiency and recycling. Simon P. Michaux, *Challenges and Bottlenecks for the Green Transition*, GTK, Feb. 23, 2023, https://unece.org/sites/default/files/2023-02/1.%20Simon%20Michaus-

Challenges%20and%20Bottlenecks%20for%20the%20Green%20Transition.pdf. It also bears noting that the long-term sufficiency of global mineral resources does not imply an absence of ethical, economic, and environmental challenges in extracting those resources. See Energy Transitions Commission, supra note 217, at 71-114; Hannah Ritchie, We have enough minerals for the energy transition, but medium-term supply is a challenge [Part 2], Sustainability by Numbers, Dec. 7, 2023,

https://www.sustainabilitybynumbers.com/p/transition-mineral-demand-part-two.

²¹⁸ See Drew Mays, Future of Solar Panel Recycling, Innovate Energy Group, July 6, 2023, https://www.ieg.solutions/post/the-future-of-solar-panel-recycling.

²¹⁹ Wang et al., *Future demand for electricity generation materials under different climate mitigation scenarios, supra* note 214, at 320. ²²⁰ Jon Hurdle, *As Millions of Solar Panels Age Out, Recyclers Hope to Cash In*, Yale Env't 360 (Feb. 28, 2023), https://e360.yale.edu/features/solar-energy-panels-recycling.

²²¹ Oscar Serpell, *Impacts of the Inflation Reduction Act on Rare Earth Elements*, Kleinman Center for Energy Policy (Sep. 24, 2022), https://kleinmanenergy.upenn.edu/news-insights/impacts-of-the-inflation-reduction-act-on-rare-earth-elements/.

²²² Biden-Harris Administration Fundamental Principles for Domestic Mining Reform, U.S. DEP'T OF THE INTERIOR (Feb. 22, 2022), https://perma.cc/6LQZ-G94Y (archived Feb. 25, 2025).

Tribal engagement.²²³ 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.²²⁴

²²³ See Recommendations to Improve Mining on Public Lands, U.S. DEP'T OF THE INTERIOR (Sept. 2023),

https://www.doi.gov/media/document/mriwg-report-final-508-pdf.

224 Biden-Harris Administration Announces \$150 Million to Strengthen Domestic Critical Material Supply Chains, U.S. DEP'T OF ENERGY (Sept. 6, 2023), https://web.archive.org/web/20250122220357/https://www.energy.gov/articles/biden-harris-administrationannounces-150-million-strengthen-domestic-critical-material (archived Jan. 22, 2025).

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."²²⁵

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. For context, the average home that is not located near power lines has a background level EMF of roughly 0.2 μ T. However, this value varies greatly depending on proximity to certain household appliances. For example, from a distance of 4 feet, an electric can opener's EMF is 0.2 μ T, but this value increases to 60 μ T from a distance of 6 inches. A 2020 academic study found that the EMF generated by turbines are approximately 0.44 μ T at a distance of 1 meter but less than 0.1 μ T at a distance of 4 meters, as shown below.

71c953b8ee02/ODH+Wind+Turbines+and+Farms+Summary+Assessment 2022.04.pdf?MOD=AJPERES.

²²⁵ OHIO DEPARTMENT OF HEALTH, WIND TURBINES AND WIND FARMS: SUMMARY AND ASSESSMENTS at 8 (Apr. 12, 2022), https://odh.ohio.gov/wps/wcm/connect/gov/816f89dc-767f-4f08-8172-

²²⁶ Lindsay C. McCallum et al., *Measuring Electromagnetic Fields (EMF) Around Wind Turbines in Canada: Is there a Human Health Concern?*, 13 Env't. Health 1, 9 (2014), https://doi.org/10.1186/1476-069x-13-9; Aris Alexias et al., Electromagnetic Field Exposure Measurement in the Vicinity of Wind Turbines, 189 Radiation Protection Dosimetry 395, 397 (2020), https://doi.org/10.1093/rpd/ncaa053; Nektarios Karanikas et al., Occupational health hazards and risks in the wind industry, 7 Energy Rep. 3750, 3752 (2021), https://doi.org/10.1016/j.egyr.2021.06.066.

²²⁷ Radiation: Electromagnetic fields, World Health Organization (August 4, 2016), https://www.who.int/news-room/questions-and-answers/item/radiation-electromagnetic-fields.

²²⁸ Id.

²²⁹ Electromagnetic Fields (EMF), WIS. DEP'T. OF HEALTH SERV. (Sept. 14, 2022), https://www.dhs.wisconsin.gov/air/emf.htm.

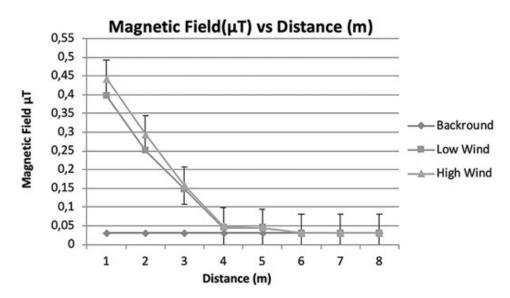


Figure 10: The EMF level, measured in microtesla (µT), is shown to drop dramatically with increase in distance from source.

Source: Alexias et al.231

These EMF levels are not dependent on wind speeds.²³²

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. "233"

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.²³⁴ Turbine blade breakage does not pose a significant threat to humans.²³⁵ 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 impossible with modern turbines due to improved engineering and the use of hazard sensors."236 Turning to all turbine blade failures, rather than just turbine blade

²³¹ *Id.*

²³² *Id.* at 398.

²³³ No Wind Turbines! Get the Facts!, SAVE PIATT COUNTY,

https://web.archive.org/web/20240901083314/http://www.savepiattcounty.org/ (archived Sept. 1, 2024).

²³⁴ How do wind turbines survive severe storms?, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, (June 20, 2017), https://perma.cc/85RN-M454 (archived Feb. 25, 2025).

²³⁵ M. McGugan et al., Damage Tolerance and Structural Monitoring for Wind Turbine Blades. 373 Phil. Transactions Royal Soc'y A, 4 (2015), https://doi.org/10.1098/rsta.2014.0077.

²³⁶ Wind Energy Projects and Safety, Dep't of Energy, https://perma.cc/3GA4-SGJQ (archived Feb. 25, 2025).

detachment, a 2015 study found that wind turbine blades fail at a rate of approximately 0.54% per year globally.²³⁷ 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."

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.²³⁹

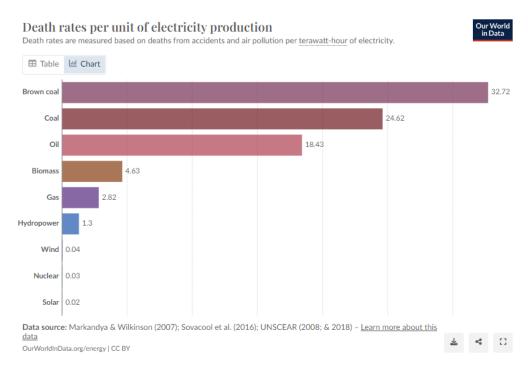


Figure 11: Death rates per unit of electricity production.

Source: Hannah Ritchie, Our World in Data.240

²³⁷ GCube Insurance Services, Inc. *GCube report: breaking blades: global trends in wind turbine downtime events* (2015), summarized in Xiao Chen, *A Critical Review of Damage and Failure of Composite Wind Turbines Blade Structures*, IOP Conference Series: Materials Sci. and Engineering (2020), at 4, https://iopscience.iop.org/article/10.1088/1757-899X/942/1/012001/pdf.

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²³⁸ Wind Vision: A New Era for Wind Power in the United States, U.S. DEPARTMENT OF ENERGY, 105 (2015), https://perma.cc/4RFC-TRK8 (archived Feb. 25, 2025).

²³⁹ Hannah Ritchie, *What are the safest and cleanest sources of energy?*, *supra* note 13. To the extent that wind-related fatalities tend to occur disproportionately during the construction phase, this analysis may overstate the fatalities per terawatt-hour of wind, which would be expected to decline over time. *See* Benjamin K. Sovacool et al., Balancing safety with sustainability: assessing the risk of accidents for modern low-carbon energy systems, 112 Journal of Cleaner Production 3952, 3960, Jan. 20, 2016, https://www.sciencedirect.com/science/article/pii/S0959652615009877 (showing in Table 5 that most wind-related deaths occurred during construction). ²⁴⁰ *Id.*

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." ¹²⁴¹

The weight of the evidence suggests that there is no direct causal correlation between low-frequency noise from wind turbines and human health.²⁴² Individual cases of sleep disturbance among people living in proximity to new wind turbines are more likely the result of annoyance about the presence of those turbines rather than inaudible noise emanating from them.²⁴³

One historical study looked at complaints filed in relation to 51 Australian wind farms from 1993 to 2012.²⁴⁴ 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.²⁴⁵ However, following the coining of the phrase "wind turbine syndrome" in a self-published book that year, there was a dramatic spike in complaints.²⁴⁶

²⁴⁶ *Id.*

²⁴¹ 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/WTSquide.pdf.

²⁴² Nathaniel Marshall et al., The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomized Crossover Study in Noise-Sensitive, Healthy Adults, 131 Env't Health Prospective, 1 (2023), https://doi.org/10.1289/EHP10757; Jenni Radun et al., Health Effects of Wind Turbine Noise and Road Traffic Noise on People Living Near Wind Turbines, 157 Renewable & Sustainable Energy Rev., 10 (2022), https://doi.org/10.1016/j.rser.2021.112040; Irene van Kamp et al., Health Effects Related to Wind Turbine Sound: An Update, 18 INT'L J. ENV'T RSCH & PUB. HEALTH, (2021), https://doi.org/10.3390%2Fijerph18179133; Wind Energy Technologies Office, Frequently Asked Questions about Wind Energy, Office of Energy Efficiency and Renewable Energy, U.S. Department OF ENERGY, https://perma.cc/26AV-OBSV (archived Feb. 25, 2025); Jesper Schmidt et al., Health Effects Related to Wind Turbine Noise Exposure: A Systematic Review, 9 PLoS One, (2014), https://doi.org/10.1371/journal.pone.0114183; NHMRC Statement: Evidence on Wind Farms and Human Health, National Health and Medical Research Council (NHMRC), Australian Government, 1 (2015), https://www.nhmrc.gov.au/file/19045/download?token=0IAl7MHu; Tracy Merlin et al., Systematic review of the human health effects of wind farms, National Health and Medical Research Council, 2013, https://www.livingstoncounty-il.org/wordpress/wpcontent/uploads/2015/01/PR-Ex.-281-2014-NHMRC-Australia.pdf; but see Richard R. James, Wind Turbine Infra and Low-Frequency Sound: Warning Signs That Were Not Heard, 32 BULLETIN OF SCIENCE, TECHNOLOGY, AND SOCIETY, 2012, https://journals.sagepub.com/doi/abs/10.1177/0270467611421845 (analyzing "historical evidence about what was known regarding infra and low-frequency sound from wind turbines and other noise sources during the period from the 1970s through the end of the 1990s" to conclude that wind energy may be causing adverse impacts to some people living near wind turbines); Anne Dumbrille et al., Wind turbines and adverse health effects: Applying Bradford Hill's criteria for causation, 6 Environmental Disease 109, 2021, at 65, https://journals.lww.com/endi/fulltext/2021/06030/wind turbines and adverse health effects applying.1.aspx (concluding that, while "[i]ncontrovertible proof of causation has tended to be an elusive goal," when a lower standard of causality is applied, "recurring sleep disturbance, anxiety, and stress" can be attributed to industrial wind turbines).

²⁴³ Irene van Kamp et al., *supra* note 242. A front-page newspaper article from 2015 that attempted to infer a direct causal relationship between turbine-related infrasound and human health impacts based on the findings of a non-peer-reviewed study was widely criticized. *See* Jacqui Hoepner & Will J Grant, *Wind turbine studies: how to sort the good, the bad, and the ugly*, Conversation, Jan. 21, 2015, https://theconversation.com/wind-turbine-studies-how-to-sort-the-good-the-bad-and-the-ugly-36548; Ketan Joshi, *Windfarm weirdness syndrome is real. Just look at our national 'debate'*, Guardian, Feb. 23, 2015,

https://www.theguardian.com/environment/2015/feb/23/windfarm-study-author-threatens-to-sue-media-watch-for-misrepresentation.

244 Fiona Crichton et al., *The Link between Health Complaints and Wind Turbines: Support for the Nocebo Expectations Hypothesis*, 2
FRONTIERS PUBL. HEALTH, 2-3 (2014), https://doi.org/10.3389/fpubh.2014.00220.

²⁴⁵ *Id.*

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." 247

Even at its peak, shadow flicker from wind turbines typically remains far weaker than what is known to trigger seizures in people with epilepsy.²⁴⁸

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.²⁴⁹ 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."²⁵⁰ If shadow flicker were to reach 3 Hz, the probability of causing a seizure in a member of the photosensitive population would be approximately 1.7/100,000.²⁵¹

Additional public-health studies have likewise found that wind turbines do not cause seizures.²⁵² Wind turbines with three blades, for example, would need to rotate at a speed of 60 rpm to cause a seizure.²⁵³ However, modern turbines typically operate at maximum speeds between 15 and 17 rpm, depending on model, well below the 60 rpm threshold.²⁵⁴

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

"The evidence is clear . . . that wind turbines present yet another threat to the lives of birds and bats." ²⁵⁵

According to the National Audubon Society, two-thirds of all North American bird species are at heightened risk of extinction due to climate change.²⁵⁶ Wildfires will destroy the nesting grounds of many species,²⁵⁷ while extreme heatwaves will render

²⁴⁷ Wind Turbines Can Trigger Epileptic Fits and Seizures, Say Scientists, DAILY MAIL (Apr. 9, 2008), https://www.dailymail.co.uk/news/article-562841/Wind-turbines-trigger-epileptic-fits-seizures-say-scientists.html.

²⁴⁸ Wind Energy Technologies Office, *Frequently Asked Questions about Wind Energy, supra* note 242.

²⁴⁹ Nektarios Karanikas et al., *Occupational Health Hazards and Risks in the Wind Industry*, 7 Energy Rep. 3750, 3752-3753 (2021), https://doi.org/10.1016/j.egyr.2021.06.066.

²⁵⁰ Wind Turbine Health Impact Study: Report of Independent Expert Panel, Massachusetts Department of Environmental Protection, 36 (2012), https://www.mass.gov/doc/wind-turbine-health-impact-study-report-of-independent-expert-panel/download.

²⁵¹ Id.

²⁵² Oleksandr Zaporozhets et al., *Environment Impact Assessment for New Wind Farm Developments in Ukraine, in* 2022 IEEE 8TH INTERNATIONAL CONFERENCE ON ENERGY SMART SYSTEMS 386, 387 (Institute of Electrical and Electronics Engineers, 2022), https://doi.org/10.1109/ESS57819.2022.9969323; Loren Knopper et al., *Wind Turbines and Human Health*, 2 Frontiers Publ. Health, 14 (2014), https://doi.org/10.3389/fpubh.2014.00063.

²⁵³ Knopper et al., *supra* note 252, at 14.

²⁵⁴ *Id*.

²⁵⁵ FAQ: Impact on Wildlife, NATIONAL WIND WATCH, https://www.wind-watch.org/fag-wildlife.php (last visited March 25, 2024).

²⁵⁶ Audubon Society, *Survival by Degrees: 389 Bird Species on the Brink*, NAT'L. AUDUBON SOC'Y., https://www.audubon.org/climate/survivalbydegrees (last visited March 25, 2024).

²⁵⁷ Audubon Society, *How Wildfires Affect Birds*, Nat'l. Audubon Soc'y., https://www.audubon.org/news/how-wildfires-affect-birds (last visited March 25, 2024).

their typical habitats uninhabitable.²⁵⁸ 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. ²⁵⁹

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.²⁶⁰ Collisions with electrical lines cause an average of 25.5 million deaths per year, a number that could grow with the construction of new transmission lines to connect wind projects (and other renewables) to the grid.²⁶¹ These mortality figures rely on studies dating back to 2013 or 2014 and may be outdated due to the fact that there were fewer wind turbines 10 years ago than there are today.²⁶² 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.²⁶³

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²⁵⁸ Audubon Society, *Survival by Degrees: 389 Bird Species on the Brink, supra* note 257.

²⁵⁹ Ic

²⁶⁰ Threats to Birds, U.S. FISH & WILDLIFE SERVICE, https://perma.cc/Q3MW-AUHH (archived Feb. 25, 2025).

²⁶¹ *Id*

²⁶² 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).

²⁶³ 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. Sovacool's 2013 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. Note that an earlier version of Sovacool's study, published in 2009, was critiqued for conflating birds and bats, among other issues; Sovacool responded directly to these critiques in a 2010 article and addressed many of them in the 2013 version of the study that is cited in this report. *See* Craig K.R. Willis, et al., *Bats are not birds and other problems with Sovacool's (2009) analysis of animal fatalities due to electricity generation*, 38 Energy Policy 2067 (2010); Benjamin K. Sovacool, *Megawatts are not megawatt-hours and other responses to Willis et al.*, 38 Energy Policy 2,070 (2010) (responding to critiques raised about an earlier version of the study on the avian benefits of wind energy).

Leading anthropogenic causes of bird mortality in the United States

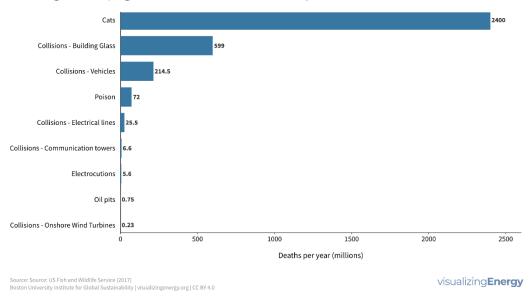


Figure 12: Leading anthropogenic causes of deaths to birds in the United States. Source: Boston University Institute for Global Sustainability.²⁶⁴

The impacts of wind development on certain bat species may be more severe. One study published in 2021 estimated that the population of hoary bats in North America could decline by 50% by 2028 without adoption of measures to reduce fatalities.²⁶⁵

However, actionable steps can be taken to reduce bird and bat fatalities from wind turbines. With respect to birds, most deaths occur when turbines are sited near nesting places. Siting facilities to avoid where birds nest, feed and mate, as well as where they stop when migrating, has proved successful at reducing fatalities.²⁶⁶ In addition, the wind turbine components that pose the greatest risk to birds are the blades and tower.²⁶⁷ The relatively simple action of painting the tower black has been shown to reduce deaths of ptarmigans (a bird in the grouse family) by roughly 48%,²⁶⁸ while painting one of the blades black has reduced deaths by 70%.²⁶⁹ Other successful methods include slowing or stopping turbine motors when

²⁶⁴ Cutler Cleveland et al., *Is Wind Energy a Major Threat to Birds?*, VISUALIZING ENERGY, Oct. 9, 2023, https://visualizingenergy.org/is-wind-energy-a-major-threat-to-birds/.

²⁶⁵ Nicholas A. Friedenberg & Winifred F. Frick, *Assessing fatality minimization for hoary bats amid continued wind energy development*, 262 BIOLOGICAL CONSERVATION, 2021, at 1, https://www.sciencedirect.com/science/article/pii/S000632072100361X; see also Minho Kim, Wind Energy Could Get Safer for Bats with New Research.

²⁶⁶ Sovacool, *The avian benefits of wind energy: A 2009 update, supra* note 263, at 19-20.

²⁶⁷ *Id.* at 23.

²⁶⁸ Bard G. Stokke et al., *Effect of tower base painting on willow ptarmigan collision rates with wind turbines*, Ecology AND EVOLUTION, Apr. 29, 2020, https://onlinelibrary.wiley.com/doi/10.1002/ece3.6307.

²⁶⁹ Roel May et al., *Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities*, Ecology & Evolution, July 26, 2020, https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.6592; see also Neel Dhanesha, *Can Painting Wind Turbine Blades Black Really Save Birds*, Audubon Magazine, Sep. 18, 2020, https://www.audubon.org/news/can-painting-wind-turbine-blades-black-really-save-birds.

vulnerable species are present, in order to reduce the likelihood of collisions.²⁷⁰ Deployment of this method in Wyoming has contributed to an 80% decline in eagle fatalities.²⁷¹ With respect to bats, strategies to minimize fatalities include curtailment (*i.e.*, stopping wind turbines from spinning under certain circumstances), as well as ultrasonic acoustic deterrents²⁷² and visual deterrents.²⁷³ In 2022, the U.S. Department of Energy awarded \$7.5 million in research grants to study bat deterrent technologies.²⁷⁴

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.²⁷⁵

False Claim #20: Offshore wind development is harmful to whales and other marine life. 276

"Record numbers of endangered whales [are] being killed by windfarms off America's East Coast'277

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.²⁷⁸

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 370.²⁷⁹ But the main causes of mortality for right whales are vessel strikes (75% of anthropogenic deaths) and entanglements in

²⁷³ Chapter 4: Minimizing Collision Risk to Wildlife During Operations: Minimization: Deterrence, Renewable Energy Wildlife Inst. (Dec. 27, 2022), https://rewi.org/quide/chapters/04-minimizing-collision-risk-to-wildlife-during-operations/minimization-deterrence/.

²⁷⁰ U.S. Dep't. of Energy Wind Energy Technologies Office, *Environmental Impacts and Siting of Wind Projects*, U.S. Dep't of Energy: OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, https://www.energy.gov/eere/wind/environmental-impacts-and-siting-wind-projects (last visited March 25, 2024).

²⁷¹ 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.

²⁷² Friedenberg & Frick, *supra* note 265, at 8.

²⁷⁴ U.S. Dep't. of Energy Wind Energy Technologies Office, *DOE Wind Energy Technologies Office Selects 15 Projects Totaling \$27 Million to Address Key Deployment Challenges for Offshore, Land-Based, and Distributed Wind*, U.S. DEP'T OF ENERGY, Sep. 21, 2023, https://www.energy.gov/eere/wind/articles/doe-wind-energy-technologies-office-selects-15-projects-totaling-27-million (archived Jan. 22, 2025).

²⁷⁵ Audubon Society, *Wind Power and Birds*, NAT'L. AUDUBON SOC'Y. (Jul. 21, 2020), https://www.audubon.org/news/wind-power-and-birds.

²⁷⁶ 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.

²⁷⁷ Mike Parker, *Record Numbers of Endangered Whales Being Killed by Windfarms Off America's East Coast*, Express, (Sept 2, 2023) https://www.express.co.uk/news/us/1808681/endangered-whales-killed-east-coast-windfarms (capitalization edited to sentence case). <a href="https://www.express.co.uk/news/us/1808681/endang

²⁷⁹ North Atlantic Right Whale, NOAA FISHERIES, https://perma.cc/R37Q-2MHB (archived Feb. 25, 2025).

fishing gear—not anything related to offshore wind development.²⁸⁰ Critically, the National Oceanic and Atmospheric Administration (NOAA) has also found no link between offshore wind surveys or development on whale deaths.²⁸¹

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. BOEM

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.²⁸⁵

By contrast, offshore oil and gas drilling routinely harms marine life, while posing a persistent risk of catastrophic outcomes.²⁸⁶ Sonar used for offshore oil and gas exploration emits much stronger pulses of sound than sonar used for wind farm surveying.²⁸⁷ The 2010 Deepwater Horizon oil spill killed millions of marine animals, including as many as 800,000 birds.²⁸⁸ 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.²⁸⁹ 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."²⁹⁰

²⁸⁰ *Id.*; Vineyard Wind 1 Offshore Wind Project Final Environmental Impact Statement Vol. I, March 2023, at 3-95, https://perma.cc/F8AD-CJ32 (archived Feb. 25, 2025).

²⁸¹ Frequent Questions – Offshore Wind and Whales, NOAA https://perma.cc/Q8PY-TTEF (archived Jan. 21, 2025).

²⁸² Vineyard Wind – NGO Agreement, Jan. 22, 2019, https://www.nrdc.org/sites/default/files/vineyard-wind-whales-agreement-20190122.pdf.

²⁸³ Vineyard Wind Final EIS, *supra* note 280, at 3-95.

²⁸⁴ *Id.* at 3-91.

²⁸⁵ Steven Degraer et al., *Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis,* 33 Oceanography 48, 49 (2020), https://doi.org/10.5670/oceanog.2020.405; *Offshore Renewable Energy Improves Habitat, Increases Fish,* Rhode Island Sea Grant (July 26, 2020), https://seagrant.gso.uri.edu/offshore-renewable-energy-improves-habitat-increases-fish/.

²⁸⁶ Marvell, *supra* note 11.

²⁸⁷ In

²⁸⁸ Martha Harbison, *More Than One Million Birds Died During the Deepwater Horizon Disaster*. Audubon, National Audubon Society (May 6, 2014), https://www.audubon.org/news/more-one-million-birds-died-during-deepwater-horizon-disaster.

²⁸⁹ National Ocean Service, *What is Ocean Acidification?*, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, https://oceanservice.noaa.gov/facts/acidification.html (last visited March 25, 2024).

²⁹⁰ Vineyard Wind Final EIS, *supra* note 280, at 3-85.

False Claim #21: Producing and transporting wind turbine components releases more carbon dioxide than burning fossil fuels.

"[W]indmills 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." ²⁹¹

On a lifecycle basis, wind power emits far less carbon dioxide than fossil fuels per kilowatt-hour of energy generated.²⁹² According to the National Renewable Energy Laboratory (NREL), the average lifecycle emissions of offshore and onshore wind turbines is 13 g CO₂-eq/KWh.²⁹³ Lifecycle emissions for fossil fuels are much higher, with natural gas and coal releasing 486 g CO₂-eq/KWh and 1001 g CO₂-eq/KWh emissions, respectively.²⁹⁴ In other words, the average lifecycle emissions of wind energy is roughly 1/77th that of coal.²⁹⁵

Manufacturing accounts for only a small percentage (2.41%) of the lifecycle emissions for wind power turbines.²⁹⁶ Most turbine emissions come from transportation, which accounts for over 90% of emissions for both offshore and onshore operations.²⁹⁷ Once operational, wind turbines create clean, emissions-free energy that offsets the carbon dioxide emissions associated with production and transportation.²⁹⁸

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." 299

Roughly 85% of the mass of a wind turbine, including the tower, gearbox, and generator, consist of metals that are easily

Developer Claims: Wind Energy Efficiency, Interstate Informed Citizens Coalition, https://iiccusa.org/developer-claims/d

²⁹² Stacey L. Dolan & Garvin A. Heath, *Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power,* 16 J. Indus. Ecology, S136-S154 (2012), https://doi.org/10.1111/j.1530-9290.2012.00464.x; Shifang Wang et al., *Life-Cycle Green-House Gas Emissions of Onshore and Offshore Wind Turbines,* 210 J. Cleaner Prod. 804, 807-808 (2019), https://doi.org/10.1016/j.jclepro.2018.11.031; Nat'l Renewable Energy Laboratory, *supra* note 68, at 3.

²⁹³ Nat'l Renewable Energy Laboratory, *supra* note 68, at 3.

²⁹⁴ *Id*.

²⁹⁵ *Id.*

²⁹⁶ Wang et al., *Life-Cycle Green-House Gas Emissions of Onshore and Offshore Wind Turbines, supra* note 292, at 807.

²⁹⁷ *Id.* at 804.

²⁹⁸ Sara Peach, *What's the Carbon Footprint of a Wind Turbine?*, YALE CLIMATE CONNECTIONS (June 30, 2021), https://yaleclimateconnections.org/2021/06/whats-the-carbon-footprint-of-a-wind-turbine/.

²⁹⁹ Donnelle Eller, *Iowa's betting big on wind energy, but it's creating a problem: What happens to the blades once they're no longer useful?*, Des Moines Register (Nov. 6, 2019), https://www.desmoinesregister.com/story/money/agriculture/2019/11/06/few-recycling-options-wind-turbine-blades-head-iowa-landfills/3942480002/.

recycled.³⁰⁰ The remaining 15%, including the blades, consist of composite-based materials, such as fiberglass, that are more difficult to recycle.³⁰¹ However, new technologies are in development for recycling turbine blades, and turbine blades are in fact being recycled in some facilities.³⁰² A recent breakthrough supported by the Department of Energy enabled all turbine components to be recycled,³⁰³ and private companies in the United States have begun developing turbine blade recycling plants.³⁰⁴

One study from 2017 estimated that global annual waste of turbine blades will reach 2.9 million metric tons per year by 2050, with a total of 43 million metrics tons in cumulative waste generated between 2018 and 2050.³⁰⁵ This is not insignificant. However, Nature Physics has projected that global cumulative waste from fossil fuel-based power generation between 2016 to 2050 is expected to produce roughly 45,550 million metric tons of coal ash alone, along with 249 million metric tons of oily sludge.³⁰⁶ In other words, the cumulative waste from coal ash is expected to be roughly 1,000 times greater than that of turbine blades, and the cumulative waste of oily sludge is expected to be about 5-6 times greater than that of turbine blades. Importantly, both coal ash and oily sludge are known to be toxic.³⁰⁷ For further context, in the United States alone, roughly 600 million short tons, or 544 million metric tons, of construction and demolition debris were generated across all sectors in 2018.³⁰⁸ In effect, the annual construction and demolition waste in the United States alone is roughly 187 times greater than the anticipated annual waste from wind turbine blades across the globe in 2050.

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

"The wind's low power density means massive materials and land/sea area requirements." ²⁰⁹

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

³⁰⁰ Muhammad Khalid et al., *Recycling of Wind Turbine Blades Through Modern Recycling Technologies: A Road to Zero Waste*, 44 RENEWABLE ENERGY FOCUS 373, 375 (2023), https://doi.org/10.1016/j.ref.2023.02.001; Alejandro de la Garza, Time, Sept. 25, 2023, https://time.com/6316828/recycling-old-wind-turbine-blades/.

³⁰¹ *Id.*

³⁰² Jonas Jensen et al., *Wind Turbine Blade Recycling: Experiences, Challenges and Possibilities in a Circular Economy*, 97 RENEWABLE & SUSTAINABLE ENERGY REV.165, 171 (2018), https://doi.org/10.1016/j.rser.2018.08.041; *Recycling & recovery of wind turbines*, Roth International, https://www.roth-international.de/en/recycling-recovery/recycling-of-wind-turbines/ (last visited June 4, 2024).

³⁰³ Wind Energy Technologies Office, *Carbon Rivers Makes Wind Turbine Blade Recycling and Upcycling a Reality with Support From DOE*, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY (October 17, 2022), https://perma.cc/2WE8-XWC3 (archived Feb. 25, 2025).

³⁰⁴ Dave Downey, *Here's How One Iowa Company is Taking Wind Turbine Blades Out of the Landfill*, WE ARE IOWA (January 24, 2023), https://www.weareiowa.com/article/tech/science/environment/recycling-wind-turbine-blades-regen-fiber-travero-alliant-energy-fiberglass-iowa/524-88fe0610-cede-4a56-a9a3-01a36319927c.

³⁰⁵ Pu Liu & Claire Y. Barlow, *Wind turbine blade waste in 2050*, 62 WASTE MANAGEMENT 229 (Apr. 2017), https://doi.org/10.1016/j.wasman.2017.02.007.

³⁰⁶ Mirletz et al., *supra* note 56, at 1376.

³⁰⁷ To

³⁰⁸ Construction and Demolition Debris: Material-Specific Data, United States Envt'l Protection Agency, https://perma.cc/C8F6-Y8AE (archived Feb. 25, 2025).

³⁰⁹ Home, NAT'L WIND WATCH, https://www.wind-watch.org/ (last visited March 25, 2024).

between 603,678 and 2,479,208 acres.³¹⁰ 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.³¹¹

Some analyses significantly overstate the amount of land required for wind energy, either by including the unused space between turbines or by using a metric called the visual footprint that measures the area from which turbines are visible. As Amory Lovins has stated, "Saying that wind turbines 'use' the land between them is like saying that the lampposts in a parking lot have the same area as the parking lot: in fact, about 99 percent of its area remains available to drive, park, and walk in." 312 When a wind turbine is sited on farmland, it typically uses only about 5% of the project area, leaving the rest available for agriculture and other purposes. 313

Moreover, depending on the location and the technology used, wind turbines can also require less land per kilowatt-hour generated than fossil fuels.³¹⁴ 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 2022.³¹⁵ The exact value depends on the type of wind tower, onshore or offshore siting, and the particular location of the turbine.³¹⁶ By comparison, natural gas values ranged from 0.6–3.3 m²/KWh, and coal values from 7.2–23.8 m²/KWh.³¹⁷ 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.³¹⁸

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.³¹⁹ 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.³²⁰

³¹⁰ Larson et al., *supra* note 107, 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. *Id.* at 243, 245.

³¹¹ Dave Merrill, *The U.S. Will Need a Lot More Land for a Zero-Carbon Economy*, Bloomberg (June 3, 2021), https://www.bloomberg.com/graphics/2021-energy-land-use-economy/.

³¹² See Amory B. Lovins, Renewable Energy's 'Footprint' Myth, 24 ELECTRICITY JOURNAL 40, 41 (2011),

https://www.sciencedirect.com/science/article/pii/S1040619011001436?via%3Dihub; Larson et al., *supra* note 107, at 245. McGill University, *Clearing the air: Wind farms more land efficient than previously thought*, SCIENCEDAILY, Apr. 17, 2024,

³¹³ McGill University, *Clearing the air: Wind farms more land efficient than previously thought*, ScienceDaily, Apr. 17, 2024 www.sciencedaily.com/releases/2024/04/240417182834.htm.

³¹⁴Carbon Neutrality in the UNECE Region: Integrated Life-cycle Assessment of Electricity Sources, UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE (UNECE), United Nations, 70 (2022), https://unece.org/sites/default/files/2022-08/LCA 0708 correction.pdf.

³¹⁵ *Id.*

³¹⁶ *Id.*

³¹⁷ *Id.*

³¹⁸ *Id.*

³¹⁹ Jessica Lovering et al., *supra* note 123, at 8.

³²⁰ *Id.*

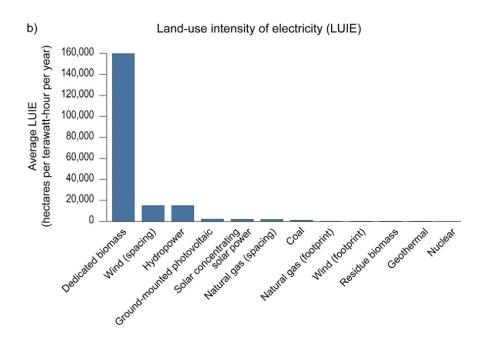


Figure 13: Average land-use intensity of electricity, measured in hectares per terawatthour per year.

Source: U.S. Global Change Research Program (visualizing data from Jessica Lovering et al.).321

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 states than others.³²² Reclamation is difficult in areas surrounding extraction sites because of frequent leakage.³²³ The land involved often suffers long-term damage and can only be used for limited purposes.³²⁴ 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

³²⁴ *Id*.

³²¹ U.S. GLOBAL CHANGE RESEARCH PROGRAM, *supra* note 124, at 32-29 (visualizing data from Jessica Lovering et al., *supra* note 123, at 8). ³²² Lauren A. Patterson, *Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements*, 51 ENVT'L SCIENCE & TECHNOLOGY 2563, 2563 (2017), https://pubs.acs.org/doi/full/10.1021/acs.est.6b05749.

³²³ Brady Allred et al., *Ecosystem Services Lost to Oil and Gas in North America*, 348 Sci 401, (2015), https://www.science.org/doi/full/10.1126/science.aaa4785.

boulders.³²⁵ There are currently over 130,000 documented orphaned oil and gas wells in the United States³²⁶; in one state, Kentucky, nearly 40% of purportedly "active" coal mines are "functionally abandoned."327

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. 328 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.³²⁹ 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.³³⁰ 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. 331

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.³³² Wind energy, in contrast, further protects local landscapes by mitigating climate impacts.

False Claim #24: Wind power, particularly offshore wind power, is too expensive.

"[W]ind 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. '833

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

well-program (archived Mar. 6, 2024).

³²⁵ See Orphaned Wells, U.S. DEP'T OF INTERIOR, https://web.archive.org/web/20250119203349/https://www.doi.gov/orphanedwells (archived Jan. 19, 2025); James Bruggers, Congressional Office Agrees to Investigate 'Zombie' Coal Mines, Inside Climate News, Jan. 12, 2024, https://insideclimatenews.org/news/12012024/kentucky-zombie-coal-mines/.

³²⁶ Federal Orphaned Well Program, U.S. Bureau of Land Management, https://web.archive.org/web/20240306020936/https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/federal-orphaned-

³²⁷ Bruggers, *supra* note 325.

³²⁸ Wind Vision: A New Era for Wind Power in the United States, supra note 238, at 139; Land and Natural Resources, ECONOMIC RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, https://perma.cc/E3VU-695G (archived Feb. 25, 2025).

³²⁹ Paul Denholm et al., Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035 at 51, Nat'l Renewable Energy LABORATORY, 2022, https://perma.cc/BV8Z-25SQ (archived Feb. 25, 2025).

³³⁰ Molly Bergen, How Wind Turbines are Providing a Safety Net for Rural Farmers, World Resources Institute (October 13, 2020), https://www.wri.org/insights/how-wind-turbines-are-providing-safety-net-rural-farmers.

³³¹ Amalesh Dhar, Perspectives on environmental impacts and a land reclamation strategy for solar and wind energy systems, 718 Science of the Total Environment 134602, 11 (2020), https://www.sciencedirect.com/science/article/pii/S0048969719345930. 332 Savannah Bertrand, Fact Sheet: Climate, Environmental, and Health Impacts of Fossil Fuels, Environmental and Energy Study Institute (December 17, 2021), https://www.eesi.org/papers/view/fact-sheet-climate-environmental-and-health-impacts-of-fossil-fuels-2021.

³³³ Problems with Offshore Wind Farms Not Worth It, NATIONAL WIND WATCH, https://www.wind-watch.org/news/2011/04/21/problemswith-offshore-wind-farms-not-worth-it/ (last visited March 25, 2024).

gas combined cycle (\$70/MWh), coal (\$117/MWh), and gas peaking (\$168/MWh).³³⁴ 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.³³⁵

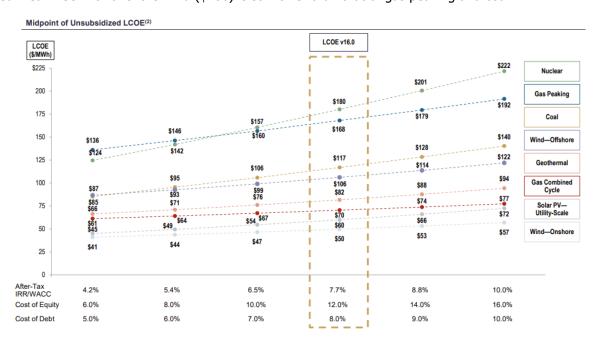


Figure 14: The range of unsubsidized LCOE for utility-scale energy sources across various cost of capital scenarios, highlighting the mean unsubsidized LCOE as of April 2023. "IRR" stands for "internal rate of return" and "WACC" stands for "weighted average cost of capital."

Source: Lazard.336

In addition, the LCOE for offshore wind power has declined substantially over the past decade.³³⁷ 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.³³⁸ Researchers further project that the average LCOE for offshore wind energy will fall to \$63/MWh by 2030.³³⁹

³³⁴ LAZARD, *supra* note 169, at 2, 6, 9.

³³⁵ Id

³³⁶ *Id.* Reproduced with permission.

³³⁷ See Walter Musial et al., Offshore Wind Market Report: 2023 Edition, Office of Energy Efficiency & Renewable Energy, U.S. DEPARTMENT OF ENERGY, at xiii, 81-83 (2023), https://perma.cc/UL2D-QLYN (archived Feb. 25, 2025); see also Ryan Wiser et al., Expert Elicitation Survey Predicts 37% to 49% Declines in Wind Energy Costs by 2050, 6 Nature Energy, 555, 557 (2021), https://doi.org/10.1038/s41560-021-00810-z.

³³⁸ Musial et al., *supra* note 337, at xiii, 81-83.

³³⁹ *Id*.

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 2021.³⁴⁰ 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 2022.³⁴¹ 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.³⁴² This includes Ocean Wind I and II, canceled in October 2023, which were anticipated to deliver over 2,200 MW of wind energy capacity.³⁴³

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.³⁴⁴ 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.³⁴⁵ 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.³⁴⁶

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."

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Wind power offers farmers the opportunity to earn additional income from leasing out their land, while also growing crops or grazing livestock.³⁴⁸ As a result, many farmers view wind turbines as beneficial for their farmland and the local

³⁴⁰ *Id.* at xii; Walter Musial et al., *Offshore Wind Market Report: 2022 Edition*, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, ix (2022), https://perma.cc/ZM9J-G95B (archived Feb. 25, 2025).

³⁴¹ Musial et al, *supra* note 337, at viii.

³⁴² See Associated Press, *In a setback for the wind industry, 2 large offshore projects are canceled in N.J.*, NPR, Nov. 1, 2023, https://www.npr.org/2023/11/01/1209986572/offshore-wind-energy-new-jersey-orsted; Heather Richards, *Offshore wind faces more financial turbulence in 2024*, EnergyWire, Jan. 8, 2024, https://www.eenews.net/articles/offshore-wind-faces-more-financial-turbulence-in-2024/.

³⁴³ Ocean Wind 2, https://oceanwindtwo.com/ (last visited March 25, 2024).

What are the Advantages and Disadvantages of Offshore Wind Farms?, AMERICAN GEOSCIENCE INSTITUTE, https://www.americangeosciences.org/critical-issues/faq/what-are-advantages-and-disadvantages-offshore-wind-farms (last visited March 25, 2024); Adrijana Buljan, Offshore Wind Costs in 2050 Could be Lower than Previously Expected, OFFSHOREWIND.BIZ (Apr. 19, 2021), https://www.offshorewind.biz/2021/04/19/offshore-wind-costs-in-2050-could-be-lower-than-previously-expected/; Laura Small et al., Fact Sheet / Offshore Wind: Can the United States Catch Up With Europe?, Environmental & Energy Study Institute, 3 (January 4, 2016), https://www.eesi.org/papers/view/factsheet-offshore-wind-2016; Wind Turbines: the Bigger, the Better, United States Dep't OF Energy, Aug. 24, 2023, https://perma.cc/4Z5T-8KBE (archived Feb. 25, 2025).

345 Laura Small et al., supra note 344, at 3.

³⁴⁶ Id. at 2; Paul R. Epstein et al., Full Cost Accounting for the Life Cycle of Coal, 1219 Ecological Econ. Rev., Annals of the N.Y. Academy of Sciences, Apr. 2011, 73-98 (Robert Costanza, Karin Limburg & Ida Kubiszewski eds., 2011), https://pubmed.ncbi.nlm.nih.gov/21332493/.

³⁴⁷ SAVE PIATT COUNTY, supra note 233.

³⁴⁸ See Wind Energy's Economic Impacts to Communities Energy, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, https://perma.cc/SNV4-NWS (archived Feb. 25, 2025); Elizabeth Weise, Wind energy gives American farmers a new crop to sell in tough times, USA Today, Feb. 16, 2020 (updated Feb. 20, 2020),

community.³⁴⁹ 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.³⁵⁰ 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."³⁵¹ Moreover, "[l]ivestock are unaffected by the presence of wind turbines and will graze right up to the base of wind turbines."³⁵²

The additional income from lease payments can help farmers keep their land in production.³⁵³ 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.³⁵⁴ In addition, property tax payments from utility-scale wind projects provide revenue to rural communities for investing in schools, roads, and bridges.³⁵⁵

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.³⁵⁶ The researchers concluded that this difference was likely due to added income the wind turbine provided.³⁵⁷

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

https://www.usatoday.com/story/news/nation/2020/02/16/wind-energy-can-help-american-farmers-earn-money-avoid-bankruptcy/4695670002/.

³⁵¹ New York Farm Bureau, Leasing Your Farmland for Wind & Solar Energy Development: A Beginner's Guide for Farmers at 3 (2014), https://www.nyfb.org/application/files/2014/9780/6349/file_y349d211hx.pdf; see also id. ("Wind turbine installations are compatible with livestock grazing and growing crops.").

³⁵⁸ Kang Xu et al., *Positive Ecological Effects of Wind Farms on Vegetation in China's Gobi Desert*, Sci. Reports 9, 6341 (2019) https://www.nature.com/articles/s41598-019-42569-0.

³⁴⁹ Kirsty Holstead et al., *Discourses of On-Farm Wind Energy Generation in the UK Farming Press*, 19 J. Env't. Pol'y & Plan. 391, 399 (2017), https://doi.org/10.1080/1523908X.2016.1224157; Sarah Mills, *Wind Energy and Rural Community Sustainability, in* Handbook Sustainability & Soc. Sci. Rsch. 215, 219-221 (Walter Leal Filho, Robert W. Marans & John Callewaert eds., 2018), https://doi.org/10.1007/978-3-319-67122-2 12.

³⁵⁰ Paul Denholm et al., *supra* note 329 at 51.

³⁵² Id.; see also id. ("Wind turbines are sturdy enough to withstand cattle using them as rubbing posts or for shade.").

Wind Energy's Economic Impacts to Communities, supra note 348; Kirsty Holstead et al., Discourses of On-Farm Wind Energy Generation in the UK Farming Press, 19 J. Env't. Pol'y & Plan. 391, 399 (2017), https://doi.org/10.1080/1523908X.2016.1224157; Mills, supra note 349, at 219-221.

³⁵⁴ Mills, *supra* note 349, at 219-221.

³⁵⁵ Wind Energy's Economic Impacts to Communities, supra note 348.

³⁵⁶ Mills, *supra* note 349, at 215, 219.

³⁵⁷ *Id.* at 215, 219-220.

³⁵⁹ Ed Adcock, *Iowa State University Research Finds Wind Farms Positively Impact Crops*, Iowa State University Extension and Outreach, Mar. 5, 2018, https://www.extension.iastate.edu/news/iowa-state-university-research-finds-wind-farms-positively-impact-crops.

360 Daniel T. Kaffine, *Microclimate effects of wind farms on local crop yields*, 96 J. Env't. Econ. Mgmt. 159, 159-160 (2019), https://doi.org/10.1016/j.jeem.2019.06.001.

same period" and that local farmers found it possible "to reconcile agriculture and wind power generation without major repercussions on rural lots."³⁶¹

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

"Subsidised wind and solar destroy far more jobs than they ever 'create"862

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 2019.³⁶³ The Department of Energy suggests that this sector could employ as many as 600,000 U.S. workers by 2050.³⁶⁴ 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.³⁶⁵

Energy Employment from 2020 to 2050 for Alternative Net-Zero Pathways

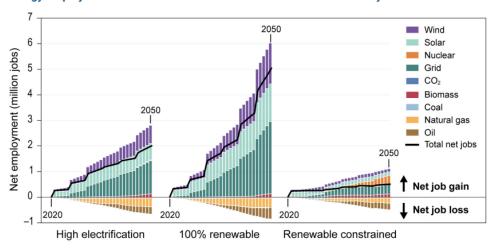


Figure 15: Energy employment from 2020 to 2050 under various U.S. net-zero GHG emissions scenarios.

Source: U.S. Global Change Research Program. 366

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³⁶¹ Manoel Fortunato Sobrinho Júnior et al., *Soil Use and Occupation of Wind Farm Agricultural Areas*, 19 Mercator - Revista de Geografia da UFC, 1, 3, (2020), https://www.redalyc.org/journal/2736/273664287012/273664287012.pdf.

³⁶² Renewable Energy Job Myth: Subsidised Wind and Solar Destroy Far More Jobs Than They Ever "Create," STOP THESE THINGS, May 11, 2020, https://stopthesethings.com/2020/05/11/renewable-energy-job-myth-subsidised-wind-and-solar-destroy-far-more-jobs-than-they-ever-create/ (capitalization edited to sentence case).

³⁶³ United States Energy & Employment Report 2022, Office of Policy, Office of Energy Jobs, U.S. Department of Energy, 24 (June 2022), https://perma.cc/2Z58-UX2F (archived Feb. 25, 2025).

³⁶⁴ Wind Vision: A New Era for Wind Power in the United States, supra note 238, at 139.

³⁶⁵ U.S. Global Change Research Program, *supra* note 124, at 32-31.

³⁶⁶ *Id.*

Most of the current domestic jobs are in manufacturing.³⁶⁷ Over 500 U.S. manufacturing facilities now specialize in producing components for wind power generation.³⁶⁸ For turbines installed in the United States, approximately 70% of tower manufacturing and 80% of nacelle assembly also occurs domestically.³⁶⁹ 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.³⁷⁰

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

"[T]he 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.³⁷² The study found that the negative impact of turbines on property values was primarily observed for urban, rather than rural, properties, and that any negative impact on property values disappeared within ten years after turbine installation.³⁷³ 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."

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. ³⁷⁵ However, home prices return to within 2% of inflation-adjusted pre-announcement levels roughly five years after the project enters operation. ³⁷⁶ 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. ³⁷⁷ The study also found no statistically-significant adverse impacts on home sale prices outside of 1.25 miles from the nearest turbine. ³⁷⁸

³⁶⁷ James Hamilton et al., *Careers in Wind Energy*, U.S. Bureau of Labor Statistics (Sept. 2010), https://www.bls.gov/green/wind_energy/wind_energy.pdf

Wind Energy Technologies Office, *Wind Manufacturing and Supply Chain*, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, https://perma.cc/JD46-GDJT (archived Feb. 25, 2025).

³⁶⁹ *Id.* The nacelle is the housing that holds the gearbox, generator, drivetrain, and brake assembly.

³⁷⁰ Fastest Growing Occupations, U.S. Bureau of Labor Statistics (Sept. 2023), https://www.bls.gov/ooh/fastest-growing.htm.

³⁷¹ FAQ: Economics, National Wind Watch, https://www.wind-watch.org/faq-economics.php (last visited March 25, 2024).

³⁷² Wei Guo et al., *The visual effect of wind turbines on property values is small and diminishing in space and time*, PNAS, March 2024, at 2, https://www.pnas.org/doi/epdf/10.1073/pnas.2309372121.

³⁷³ *Id.* at 3.

³⁷⁴ *Id.* at 3-4.

³⁷⁵ Eric J. Brunner et al., *Commercial wind turbines and residential home values: New evidence from the universe of land-based wind projects in the United States*, 185 ENERGY POLICY 113837, at 1 (2023), https://www.sciencedirect.com/science/article/pii/S0301421523004226?via%3Dihub.

³⁷⁶ *Id.* at 1.

³⁷⁷ *Id.* at 9-10.

³⁷⁸ *Id.* at 7, 10.

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%.³⁷⁹ The study also found that the farther a turbine was placed from a home, the less impact it had on property value.³⁸⁰ The greatest impact, a price drop of 8.3%, occurred when a large turbine (>150 meters) was placed within 750 meters of a home.³⁸¹ The greatest impact from a medium sized turbine (50–150 meters) was 3.4%.³⁸² Beyond 2,250 meters, moreover, the 2021 study found no discernible price impact from turbines.³⁸³ A separate study found no impact beyond 3 km. ³⁸⁴ The figure below shows how, for the 2021 study, size and distance of a turbine impacted property value.³⁸⁵

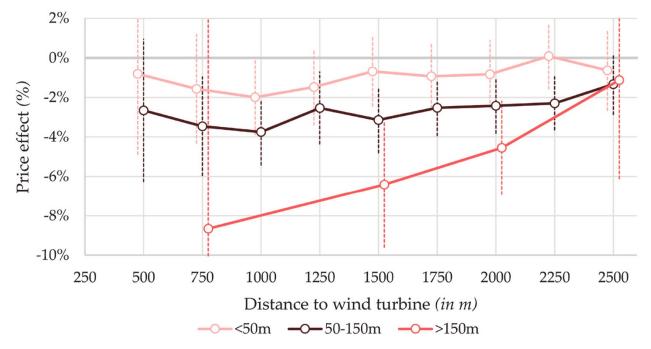


Figure 16: Graph shows how different size of wind turbines, and distance from property, affects home value. Turbine height is calculated as axis height plus half of the rotor blade diameter.

Source: Martijn Dröes et al. 386

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. ³⁸⁷ While yet another academic study of roughly 50,000 home transactions

³⁷⁹ Martijn Dröes et al., *Wind Turbines, Solar Farms, and House Prices*, 155 ENERGY POL'Y, 2 (2021), https://doi.org/10.1016/j.enpol.2021.112327.

³⁸⁰ *Id*. at 8.

³⁸¹ *Id.*

³⁸² *Id.*

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³⁸⁴ Cathrine Jensen et al., *The Impact of On-Shore and Off-Shore Wind Turbine Farms on Property Prices*, 116 Energy Pol'y 54, 50-59 (2018), https://doi.org/10.1016/j.enpol.2018.01.046.

³⁸⁵ Martijn Dröes et al., *supra* note 379, at 8.

³⁸⁶ *Id.*

³⁸⁷ Corey Lang et al., *The Windy City: Property Value Impacts of Wind Turbines in an Urban Setting,* 44 ENERGY ECON. 413, 420-421 (2014), https://doi.org/10.1016/j.eneco.2014.05.010.

(spread across nine states) within 10 miles of a turbine site likewise found no statistically significant evidence of a price change. ³⁸⁸ 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%. ³⁸⁹ Among the fossil fuel power plants in the study sample, 92% were natural gas plants. ³⁹⁰

Finally, these impacts can be mitigated. For example, multiple studies recommend clustering turbines within wind farms.³⁹¹ One of these studies found that adding a turbine within two kilometers of an existing turbine had a statistically insignificant impact on house prices.³⁹² 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.³⁹³

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." ¹⁸⁹⁴

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, ³⁹⁵ and energy efficiency and grid flexibility mechanisms can support a renewable energy-based grid. ³⁹⁶ Hydropower has also been found to support wind and solar by compensating for intermittency in those sources. ³⁹⁷ Moreover, building more long-distance transmission infrastructure can enable greater reliance on wind and solar generation, ³⁹⁸ and linking offshore wind projects through offshore transmission networks is also expected to enhance grid reliability. ³⁹⁹ A National Renewable Energy Laboratory report concluded that "wind power can support power system reliability" by providing "active power controls,"

³⁹¹ Cathrine Jensen et al., *supra* note 384, at 51; Martijn Dröes et al., *supra* note 379, at 7.

³⁸⁸ Lucas Nelsen, *Are Property Values Affected by Wind Farms?*, Center for Rural Affairs (July 19, 2018), https://www.cfra.org/blog/are-property-values-affected-wind-farms.

³⁸⁹ Lucas Davis, *The Effect of Power Plants on Local Housing Value and Rents*, 93 Rev. Econ. Stat. 1391 (2011), https://doi.org/10.1162/rest a 00119.

³⁹⁰ *Id.* at 1400.

³⁹² Martijn Dröes et al., *supra* note 379, at 7.

³⁹³ See Daniel R. Houck, Review of wake management techniques for wind turbines, 25 Wind Energy 195, 195-96 (2022), https://onlinelibrary.wiley.com/doi/epdf/10.1002/we.2668.

³⁹⁴ Id.

³⁹⁵ See Eric Larson et al., supra note 107, 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).

³⁹⁶ See Amory B. Lovins, *Reliably integrating variable renewables: Moving grid flexibility resources from models to results, supra* note 190.

³⁹⁷ Rui Shan et al., *Complementary relationship between small-hydropower and increasing penetration of solar photovoltaics: Evidence from CAISO*, 155 Renewable Energy 1139, 1140 (2020).

³⁹⁸ 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").

³⁹⁹ OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEP'T OF ENERGY, ATLANTIC OFFSHORE WIND TRANSMISSION STUDY, at vii (March 2024), https://www.nrel.gov/docs/fy24osti/88003.pdf.

⁴⁰⁰ Erik Ela et al., *Active Power Controls from Wind Power: Bridging the Gaps* at xi, Nat'l Renewable Energy Laboratory, Jan. 2014, https://www.nrel.gov/docs/fy14osti/60574.pdf; see also NREL Report Redefines Wind as a Grid Stabilizer, Not a Liability, Nat'l Renewable Energy Laboratory, Jan. 2014, https://www.nrel.gov/docs/fy14osti/60993.pdf; Weihang Yan et al., Synchronous Wind: Evaluating the Grid Impact of Inverterless Grid-Forming Wind Power Plants, Nat'l Renewable Energy Laboratory, 2023 (preprint), https://www.nrel.gov/docs/fy23osti/84609.pdf.

which are mechanisms for balancing the power generated by wind farms with the power consumed on the electricity grid.⁴⁰¹ 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.⁴⁰²

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 energy production) to 435 billion kilowatt-hours (10.3% of total energy production). 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.

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. Today, Iowa is considered one of the states with the most reliable energy systems. 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. Yet even with this increased reliance on wind power, California's grid reliability has remained consistent, and largely above national averages. 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. 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.

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⁴⁰¹ Jan-Willem van Windergarden et al., *Active Power Control of Waked Wind Farms*, 50 IFAC 4484, 4484, (July 2017), https://www.sciencedirect.com/science/article/pii/S240589631730722X.

⁴⁰² Joshua W. Busby et al., *Cascading risks: Understanding the 2021 winter blackout in Texas*, 77 Energy Research and Social Science 102106 (2021), 1-4, https://www.sciencedirect.com/science/article/pii/S2214629621001997; Adriana Usero & Salvador Rizzo, *'Frozen windmills' aren't to blame for Texas's power failure*, Wash. Post, Feb. 18, 2021,

https://www.washingtonpost.com/politics/2021/02/18/frozen-windmills-arent-blame-texass-power-failure-neither-is-green-new-deal/; Dionne Searcey, *No, Wind Farms Aren't the Main Cause of the Texas Blackouts*, N.Y. TIMES, Feb. 17, 2021 (updated May 3, 2021), https://www.nytimes.com/2021/02/17/climate/texas-blackouts-disinformation.html.

⁴⁰³ Wind Explained: Electricity Generation from Wind, U.S. ENERGY INFORMATION ADMINISTRATION, https://perma.cc/VYR6-3C7C (archived Feb. 25, 2025).

⁴⁰⁴ *Id*.

⁴⁰⁵ Niccolo Conte, *Which US State Generates the Most Wind Power? There's a Clear Winner*, World Economic Forum (April 26, 2022), https://www.weforum.org/agenda/2022/04/us-wind-electricity-generation-renewable-energy/.

⁴⁰⁶ Chazz Allen, *Iowa Leads in Homegrown, Reliable, Renewable Energy*, GAZETTE (November 12, 2022) https://www.thegazette.com/quest-columnists/iowa-leads-in-homegrown-reliable-renewable-energy/.

⁴⁰⁷ Energy Rankings: Measuring States' Energy Infrastructure, U.S. News and World Report, https://www.usnews.com/news/best-states/rankings/infrastructure/energy (last visited March 25, 2024).

⁴⁰⁸ California Energy Comm'n, *Total System Electric Generation 2009-2022 with totals*, California Energy Commission, (2022), https://www.energy.ca.gov/media/7311.

⁴⁰⁹ California Energy Comm'n, *Electric System Reliability Annual Reports*, California Energy Commission, (2022), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/electric-reliability/electric-system-reliability-annual-reports.

⁴¹⁰ Lauren Sommer, *California Just Ran on 100% Renewable Energy, but Fossil Fuels Aren't Fading Away Yet*, NPR (May 13, 2022), https://www.npr.org/2022/05/07/1097376890/for-a-brief-moment-calif-fully-powered-itself-with-renewable-energy.

⁴¹¹ Georgina Rannard, *Wind Generated a Record Amount of Electricity in 2022*, BBC NEWS, (January 6, 2023), https://www.bbc.com/news/science-environment-64179918.

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."

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 (dBAs),⁴¹³ except in a worst-case scenario in which noise "might reach slightly above 55 dBA."⁴¹⁴ The DOE provides as a point of comparison that sounds at 60 dBA resemble those of a residential air conditioner 20 feet away, whereas sounds at 50 dBA resemble those of a residential air conditioner 50 feet away.⁴¹⁵

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. 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. For context, a soft whisper is 30 decibels, a refrigerator hum is 40 decibels, and a typical conversation takes place at 60 decibels. The CDC has set 70 decibels as the cutoff at which prolonged exposure can cause annoyance and hearing damage. 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.

⁴¹⁶ Chun-Hsiang Chiu et al., *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.

⁴¹² Noise Complaints on Rise with New Industrial Wind Power Projects, NATIONAL WIND WATCH, https://www.wind-watch.org/faq-noise.php (last visited March 25, 2024).

⁴¹³ A-weighted decibel measurements factor into their assessment how the human ear actually perceives sound. *See Fundamentals of Noise and Sound,* Federal Aviation Administration, https://www.faa.gov/regulations-policies/policy-guidance/noise/basics (last visited March 25, 2024).

⁴¹⁴ RAIL TIE WIND PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT, Nov. 2021, at ES-vi, https://www.energy.gov/sites/default/files/2021-11.pdf.

⁴¹⁵ *Id.* at 3-104.

⁴¹⁸ What Noises Cause Hearing Loss?, Centers for Disease Control and Prevention (CDC), https://www.cdc.gov/nceh/hearing loss/what noises cause hearing loss.html (last visited March 25, 2024) 419 Id.

⁴²⁰ Wind Turbines, Environmental Protection Agency, Ministry of Environment of Denmark, https://eng.mst.dk/air-noise-waste/noise/wind-turbines/noise-from-wind-turbines/ (last visited March 25, 2024).

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." 421

EVs are essential to reducing greenhouse gas (GHG) emissions and the use of fossil fuels that cause those emissions.⁴²² 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.⁴²³ 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."⁴²⁴ 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.⁴²⁵

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.⁴²⁶ 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.⁴²⁷

⁴²¹ Steve Forbes, *The Expensive and Harmful Truth About Electric Vehicles*, Forbes, Jan. 6, 2023, https://www.forbes.com/sites/steveforbes/2023/01/06/the-expensive-and-harmful-truth-about-electric-vehicles/.

⁴²² See Divya Singh et al., *Does electric vehicle adoption (EVA) contribute to clean energy? Bibliometric insights and future research agency*, 8 Cleaner & Responsible Consumption 100099, 1 (2023),

https://www.sciencedirect.com/science/article/pii/S2666784322000535#bib4; Electric Vehicle Benefits and Considerations, Alternative Fuels Data Centre, Office of Energy Efficiency and Renewable Energy, US Department of Energy, https://perma.cc/VN3M-HAEJ (archived Feb. 25, 2025).

⁴²³ Electric Vehicle Myths, supra note 19.

⁴²⁴ IPCC, Climate Change 2022: Mitigation of Climate Change (2022), 271, https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC AR6 WGIII FullReport.pdf.

⁴²⁵ All-Electric Vehicles, U.S. DEPT. OF ENERGY, https://perma.cc/Y8JT-LHZ2 (archived Feb. 25, 2025); see also Eric Larson et al., supranote 107, at 40.

⁴²⁶ Electric Vehicle Myths, supra note 19.

⁴²⁷ *Id*.

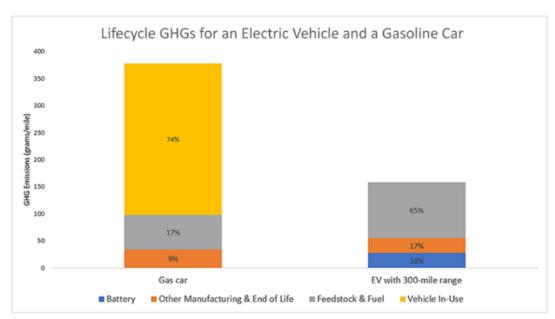


Figure 17: Break down of lifecycle emissions for electric and gasoline cars. This figure is based on the following assumptions: a vehicle lifetime of 173,151 miles for both the EV and gas car; a 30.7 MPG gas car; and U.S. average grid emissions.

Source: EPA.428

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. ⁴²⁹ 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. Those drivers in the United States who would like to ensure that they are charging their

⁴²⁸ *Id.*

⁴²⁹ 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."

⁴³⁰ Johannes Buberger et al., *Total CO2-Equivalent Life-Cycle Emissions from Commercially Available Passenger Cars*, 159 Renewable & Sustainable Energy Rev, 10 (2022), https://doi.org/10.1016/j.rser.2022.112158.

⁴³¹ *Id.*; see also Paul Wolfram et al., *Pricing Indirect Emissions Accelerates Low—Carbon Transition of US Light Vehicle Sector*, 12 Nature Commc'ns, (2021), https://doi.org/10.1038/s41467-021-27247-v.

⁴³² Power Sector Carbon Index, Scott Institute for Energy Innovation, https://emissionsindex.org/ (last visited March 25, 2024).

EVs with the cleanest possible energy, the Environmental Protection Agency's Energy Star program helps drivers determine which chargers rely on renewable energy sources. 433

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."⁴³⁴

EV manufacturing need not result in fewer jobs in the U.S. automobile industry.⁴³⁵ 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.⁴³⁶ 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."⁴³⁷

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.⁴³⁸ In 2021, the domestic EV industry employed roughly 106,000 workers, more than a 90% increase from 2016 (roughly 55,000 jobs).⁴³⁹ In 2021 alone, the number of domestic jobs in the EV industry grew by over 26%.⁴⁴⁰

Moreover, economic incentives from the 2022 Inflation Reduction Act have increased domestic production and strengthened domestic supply chains.⁴⁴¹ The Inflation Reduction Act provides a customer rebate of up to \$7,500 for EVs produced in the

⁴³³ Charge Your Electric Vehicle Sustainably With Green Power, Energy Star, U.S. Environmental Protection Agency, 2, https://perma.cc/6LOU-2BJU (archived Feb. 25, 2025).

⁴³⁴ Angelo Fichera, *Trump Autoworkers Speech Fact Check: What of Electric Vehicles?*, N.Y. TIMES (Sept. 28, 2023, last updated Oct. 9, 2023), https://www.nytimes.com/2023/09/28/us/politics/trump-fact-check-electric-vehicles.html (quoting Donald Trump).

⁴³⁵ See Emily Pontecorvo, *There's Surprisingly Little Evidence That EVs Will Require Fewer Workers*, HEATMAP (Oct. 6, 2023), https://heatmap.news/electric-vehicles/evs-trump-uaw-jobs-evidence.

⁴³⁶ 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.

⁴³⁷ 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.

⁴³⁸ ENVT'L DEFENSE FUND, U.S. ELECTRIC VEHICLE MANUFACTURING INVESTMENTS AND JOBS: CHARACTERIZING THE IMPACTS OF THE INFLATION REDUCTION ACT AFTER 1 YEAR at 2 (2023), https://www.edf.org/sites/default/files/2023-08/EDF%20WSP%20EV%20report%208-16-23%20FINAL%20FINAL.pdf.

⁴³⁹ BW Research Partnership, *Energy Employment by State – 2020*, 147 (2020), https://www.usenergyjobs.org/s/USEER-Energy-Energy-Energy Energy Energy Energy Energy Energy and Employment Report 2022, Office of Policy, Office of Energy Jobs, U.S. Department of Energy, 141-143 (2022), https://perma.cc/2Z58-UX2F (archived Feb. 25, 2025).

⁴⁴⁰ DOE Report Finds Energy Jobs Grew Faster Than Overall U.S. Employment in 2021, U.S. DEPARTMENT OF ENERGY (June 28, 2022), https://perma.cc/6CQX-S4CN (archived Feb. 25, 2025).

⁴⁴¹ See Envt'l Defense Fund, supra note 438, at 4-5; Leo Banks, How Inflation Reduction Act Electric Vehicles Incentives Are Driving a U.S. Manufacturing Renaissance, Center for American Progress, Nov. 22, 2023, https://www.americanprogress.org/article/how-inflation-reduction-act-electric-vehicle-incentives-are-driving-a-u-s-manufacturing-renaissance/.

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.⁴⁴² 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.⁴⁴³ 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 2027.⁴⁴⁴

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), although 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-days 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 ports, more than tripling those in operation, from approximately 52,500 in 2017 to approximately 184,000 in 2023. For comparison, there are approximately 150,000 gas stations in the United States, which likely include about 900,000 to 1.8 million individual pumps. In addition, the United States installed 6,300 fast chargers in 2022, which

⁴⁴² Owen Minott et al., *IRA EV Tax Credits: Requirement for Domestic Manufacturing,* BIPARTISAN POLICY CENTER (Feb. 24, 2023), https://bipartisanpolicy.org/blog/ira-ev-tax-credits/.

⁴⁴³ Envt'l Defense Fund, *supra* note 438, at 4-5.

⁴⁴⁴ Gartner Outlines a New Phase for Electric Vehicles, Gartner, March 7, 2024, https://www.gartner.com/en/newsroom/press-releases/2024-03-07-gartner-outlines-a-new-phase-for-electric-vehicles.

⁴⁴⁵ Former President Donald Trump, Campaign Speech in Ankeny, Iowa, CSPAN (Dec. 2, 2023), https://www.c-span.org/video/?532073-1/president-trump-delivers-remarks-ankeny-iowa.

⁴⁴⁶ Electric Vehicle Myths, supra note 19; Model Year 2021 All-Electric Vehicles Had a Median Driving Range about 60% That of Gasoline Powered Vehicles, DEP'T OF ENERGY, Jan. 17, 2022, https://www.energy.gov/eere/vehicles/articles/fotw-1221-january-17-2022-model-year-2021-all-electric-vehicles-had-median; Evolution of average range of electric vehicles by powertrain, 2010-2021, IEA (last updated May 19, 2022), https://www.iea.org/data-and-statistics/charts/evolution-of-average-range-of-electric-vehicles-by-powertrain-2010-2021.

⁴⁴⁷ Dep't of Energy, supra note 446.

⁴⁴⁸ Electric Vehicle Myths, supra note 19.

⁴⁴⁹ Zachary A. Needell et al., *Potential for Widespread Electrification of Personal Vehicle Travel in the United States*, NATURE ENERGY 1, 16112 (2016). https://doi.org/10.1038/nenergy.2016.112.

⁴⁵⁰ Evolution of average range of electric vehicles by powertrain, 2010-2021, supra note 446.

⁴⁵¹ Charging Electric Vehicles at Home, U.S. Dep't of Energy, https://perma.cc/9RYP-FS93 (archived Feb. 25, 2025).

⁴⁵² Electric Vehicle Charging Infrastructure Trends, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, https://afdc.energy.gov/fuels/electricity infrastructure trends.html (last visited May 16, 2024).

⁴⁵³ Service Station FAQs, AMERICAN PETROLEUM INSTITUTE, https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/service-station-faqs (last visited March 25, 2024); What is the future of gas stations vs EV chargers?, Enel X Way, Nov. 21, 2022, https://www.enelxway.com/us/en/resources/blog/what-is-the-future-of-gas-stations-vs-ev-chargers.

brought the national total to 28,000 fast chargers.⁴⁵⁴ The next year, in 2023, the United States installed 10,651 public fast chargers, 56% more than in 2022.⁴⁵⁵ 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 2030.⁴⁵⁶ 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 2021.⁴⁵⁷

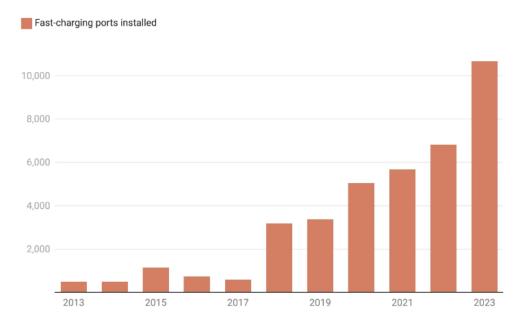


Figure 18: Representation of fast-charging ports installed in the United States each year from 2013 to 2023. **Source: Michael Thomas, Distilled.**⁴⁵⁸

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⁴⁵⁴ International Energy Agency, Global EV Outlook 2023, 45 (2023), https://iea.blob.core.windows.net/assets/dacf14d2-eabc-498a-8263-9f97fd5dc327/GEVO2023.pdf.

⁴⁵⁵ Michael Thomas, *American Is Finally Building a Nationwide EV Charging Network,* DISTILLED, Mar. 27, 2024, https://www.distilled.earth/p/america-is-finally-building-a-nationwide.

⁴⁵⁶ FACT SHEET: Biden-Harris Administration Announces New Standards and Major Progress for a Made-in-America National Network of Electric Vehicle Chargers, WHITE HOUSE (February 15, 2023),

https://web.archive.org/web/20250117193038/https://www.whitehouse.gov/briefing-room/statements-releases/2023/02/15/fact-sheet-biden-harris-administration-announces-new-standards-and-major-progress-for-a-made-in-america-national-network-of-electric-vehicle-chargers/ (archived Jan. 17, 2025).

⁴⁵⁷ INTERNATIONAL ENERGY AGENCY, GLOBAL EV OUTLOOK 2023, supra note 454, at 45.

⁴⁵⁸ Michael Thomas, *supra* note 455 (reproduced with permission).

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

"Temperature affects EVs in bad ways." 459

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. ⁴⁶⁰ 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%. ⁴⁶¹ 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. ⁴⁶²

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.⁴⁶³ As with EVs, decreased fuel efficiency for conventional gasoline cars in extreme weather is partially attributable to increased reliance on HVAC systems.⁴⁶⁴ Both EVs and gasoline-powered cars are likewise susceptible to cold temperatures lowering tire pressure.⁴⁶⁵

Data from a roadside assistance company in Norway suggests that, by one metric, EVs may actually be more reliable than gasoline-powered cars in the cold. In particular, whereas internal combustion engines sometimes have trouble starting in the cold, this problem appears to be less common for EVs: while 23% of cars in Norway are EVs, only 13% of reported cases involving cars that failed to turn on in the cold were EVs. 467

⁴⁵⁹ Federico Alcala, *15 Disadvantages of Electric Cars*, TopSpeed (Jul. 6, 2023), https://www.topspeed.com/disadvantages-of-electric-cars/#charging-times-are-still-not-on-par-with-filling-up-gas.

⁴⁶⁰ AAA Electric Vehicle Range Testing, AMERICAN AUTOMOBILE ASSOCIATION, 32, 51 (2019), https://www.aaa.com/AAA/common/AAR/files/AAA-Electric-Vehicle-Range-Testing-Report.pdf. ⁴⁶¹ Id.

⁴⁶² Carolyn Fortuna, *Why Heat Pumps Are Essential for EVs When the Weather Is Cold*, CleanTechnica, Jan. 22, 2024, https://cleantechnica.com/2024/01/22/why-heat-pumps-are-essential-for-evs-when-the-weather-is-cold; Shannon Osaka, *Why you might want a heat pump in your electric car*, Washington Post, Jan. 7, 2023, https://www.washingtonpost.com/climate-solutions/2023/01/07/electric-vehicles-cold-winter-range/.

⁴⁶³ Fuel Economy in Cold Weather, U.S. Dep'τ. Energy, https://www.energy.gov/energysaver/fuel-economy-cold-weather (last visited March 25, 2024).

⁴⁶⁴ *Id.*; Fuel Economy in Hot Weather, U.S. DEP'T ENERGY, https://www.energy.gov/energysaver/fuel-economy-hot-weather (last visited March 25, 2024).

⁴⁶⁵ See Sydnie Gjerald, Winter Range: ICE vs EV, Utilmarc, Jan. 4, 2022, https://www.utilimarc.com/blog/winter-range-ice-vs-ev/; Fuel Economy in Cold Weather, supra note 463.

⁴⁶⁶ 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/ (noting that EVs are newer on average than other types of cars). 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.