



Debate Brief

“Resolved: ‘Net-Zero by 2050’ is both achievable and necessary to address climate change.”

“[O]ur world needs climate action on all fronts.... This is the moment for all G20 members to come together in a joint effort, pooling their resources and scientific capacities as well as their proven and affordable technologies through the public and private sectors to make carbon neutrality a reality by 2050. ...We have never been better equipped to solve the climate challenge, but we must move into warp speed climate action now.”

—António Guterres, United Nations Secretary General, 2023

“It would be contrary to sound policy for business or any organization to engage in an effort to dominate political or governmental action by meddling in what does not concern them. ...But when industry will be affected by governmental action it might be heard sympathetically and without implication of seeking domination contrary to public interest. We cannot have employment and prosperity except on the basis of justice to business.”

—Calvin Coolidge, “Calvin Coolidge Says” December 30, 1930

“[I]f you see ten troubles coming down the road, you can be sure that nine will run into the ditch before they reach you and you have to battle with only one of them.”

—Calvin Coolidge, as recounted by Herbert Hoover

ABOUT THE COOLIDGE FOUNDATION

The Calvin Coolidge Presidential Foundation is the official foundation dedicated to preserving the legacy and promoting the values of America's 30th president, Calvin Coolidge, who served in office from August 1923 to March 1929. These values include civility, bipartisanship, and restraint in government, including wise budgeting. The Foundation was formed in 1960 by a group of Coolidge enthusiasts, including John Coolidge, the president's son. It maintains offices at the president's birthplace in Plymouth Notch, Vermont, and in Washington, D.C. The Foundation seeks to increase Americans' understanding of President Coolidge, his era, and the values he respected.

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BACKGROUND

Over the past few decades, climate change has become one of the most contentious and polarizing areas of public policy. Some people believe that climate change is the most urgent threat facing humanity. Others believe climate change is nothing to be concerned about at all. There are also people in the “middle” who believe that some level of concern and action is perhaps warranted, but who have a wide range of opinions over exactly which actions would be appropriate and effective. According to the Pew Research Center, about 24% of Americans believe that global climate change is affecting their local community a great deal, 39% believe it is having some effect, and 37% believe it is not having any effect.¹

Although it is difficult to prove definitively, many climate scientists and scientific agencies argue that the evidence shows that human activities have warmed Earth’s surface and are warming Earth’s climate.² Peer-reviewed studies show that climate-warming trends over the past century may be due to human activities such as the burning of fossil fuels.³ Climate activists say that rising temperatures have already resulted in more frequent and severe heatwaves, extreme weather events, sea-level rise, and the disruption of ecosystems. But even if there is growing consensus in the scientific and advocacy communities about climate change, there is still very little consensus on what, if anything, the United States should do about the issue from the standpoint of official national policy.

The Goal of “Net-Zero by 2050”

One of the most ambitious proposals to address climate change has been advanced by the United Nations in its “Paris Agreement” of 2015. Among other things, it calls for nations to substantially reduce their global greenhouse gas emissions to limit the global temperature increase in this century to 2 degrees Celsius (while pursuing efforts to limit the increase even further to 1.5 degrees). It proposes that countries pursue a goal of achieving “net-zero emissions” by the year 2050.

Net-Zero refers to the balance between the amount of greenhouse gases (GHGs) emitted into the atmosphere and the amount removed or offset. Achieving net-zero emissions implies that the total GHGs released into the atmosphere is equal to the amount removed, effectively resulting in no additional contribution to global warming. The year 2050 specifies the timeframe in which the world aims to achieve net-zero emissions.

Is it Necessary and Achievable?

The vigorous public debate over whether achieving net-zero emissions by 2050 is both necessary and achievable encapsulates the complexity of the climate challenge. On one hand,

¹ [“Two-Thirds of Americans Think Government Should Do More on Climate”](#) Pew Research Center. June 23, 2020.

² [“Scientific Consensus: Earth’s Climate is Warming”](#) NASA.gov. Accessed October 9, 2023.

³ M. Lynas, et al, [“Greater than 99% consensus on human caused climate change in the peer-reviewed scientific literature”](#), *Environmental Research Letters*. Vol. 16 No. 11. (19 October 2021)

proponents of the proposal argue that this ambitious target is an essential step to safeguarding the planet from catastrophic climate impacts. They emphasize the urgency of the situation, the economic opportunities associated with transitioning to a low-carbon economy, the potential for technological innovation, and the imperative of international cooperation.

On the other hand, skeptics raise valid concerns. They point to the economic challenges of transitioning away from fossil fuels, the technological and infrastructure barriers that must be overcome, the potential for inequitable social impacts, and the risks associated with relying on unproven technologies.

The debate over whether to pursue net-zero emissions by 2050 as a matter of national policy represents a pivotal moment in the response to climate change. It is an issue that deserves careful consideration, rigorous analysis, and realistic solutions.

President Coolidge, whose term in office spanned 1923-1929, had to contend with dilemmas about natural disaster response and issues that involved business regulation, but he never had to make policy on an issue quite like climate change. What he would have thought, and what he would have said, we will never know. The question therefore falls to you: is “Net-Zero by 2050” achievable and necessary to address climate change?

KEY TERMS

Climate Change – A long-term change in the average temperatures and/or the typical weather patterns of a local, regional, or global climate. Includes changes in weather phenomena such as flooding, droughts, snowfall, and storms.

Global Warming – A term that specifically refers to rising average temperatures on Earth.

Greenhouse Gas (GHG) – Greenhouse gases are gases, such as carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), that trap heat in the Earth's atmosphere. Too little greenhouse gas in the atmosphere would make Earth too cold to inhabit, while too much greenhouse gas would make the Earth too warm.

Carbon Emissions – The term carbon emissions, or “CO₂ emissions,” refers to the release of carbon dioxide (CO₂) into the atmosphere, primarily from human activities like burning fossil fuels.

Mitigation – Mitigation in the context of climate change refers to efforts to reduce or prevent the emission of greenhouse gases and minimize their impact on the climate. This includes actions like transitioning to renewable energy sources and increasing energy efficiency.

Carbon Neutral – When an entity such as a company or country has balanced its carbon emissions by removing or offsetting an equivalent amount of CO₂ from the atmosphere, typically through activities like reforestation or deploying carbon capture technologies.

Renewable Energy – Energy derived from sources that are naturally replenished, such as sunlight (solar), wind (wind power), and flowing water (hydroelectric). These sources produce little to no greenhouse gas emissions during energy generation, so they are important in efforts to reduce carbon emissions.

The Paris Agreement – The Paris Agreement is an international treaty adopted in 2015 under the United Nations Framework Convention on Climate Change (UNFCCC). It aims to limit global warming to a point that is less than 1.5°C to 2°C above pre-industrial levels. The agreement lays out commitments by nations to reduce emissions and enhance climate resilience. It was signed by about 200 countries in 2016 and re-signed by the U.S. in 2021.⁴

Intergovernmental Panel on Climate Change (IPCC) – Established by the World Meteorological Organization and the United Nations Environment Programme in 1988, the Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental body of the United Nations. Its job is to advance scientific knowledge about climate change caused by human activities. It is headquartered in Switzerland.

⁴ Einhorn, S. “Climate Change: What They Rarely Teach in College” 2023. p142

AFFIRMATIVE ARGUMENTS

1. Achieving net-zero emissions by 2050 is necessary because climate change is an urgent global crisis that requires immediate action.

According to the Intergovernmental Panel on Climate Change (IPCC), to limit global warming to 1.5°C and avoid catastrophic consequences, we must achieve net-zero emissions by mid-century. “Ambitious mitigation actions are indispensable to limit warming to 1.5°C while achieving sustainable development and poverty eradication,” argued the IPCC in its landmark Special Report.⁵ Delaying action increases the risks of severe climate impacts.

Achieving net-zero emissions by 2050 is not just an ambitious goal but a necessary one because climate change presents an unprecedented global crisis that demands immediate and comprehensive action. The urgency stems from the fact that climate change is already causing severe and far-reaching impacts on ecosystems, economies, and human societies worldwide. Increased droughts, wildfires, and floods “have exposed millions of people to acute food and water insecurity, especially in Africa, Asia, Central and South America, on Small Islands and in the Arctic.”⁶

Heatwaves have become more frequent and more dangerous. According to the U.S. Global Change Research Program, heat waves in major U.S. cities have increased from an average of two heat waves per year during the 1960s to more than six per year during the 2020s.⁷ Moreover, across U.S. cities in general, the heatwave season in recent years is 49 days longer than it was in the 1960s.⁸

If global warming continues unabated, the world could experience catastrophic consequences. The precautionary principle, which states that it is wise to take protective action even before there is complete scientific proof about risks and the efficacy of a particular solution, compels us to take action now. Climate change poses a wide variety of risks, including significant economic risks such as damage to infrastructure and property, as well as public health risks, such as increased spread of vector-borne diseases and exacerbating respiratory conditions due to air pollution.⁹

⁵ [“Special Report: Global Warming of 1.5°C”](#) IPCC. October 8, 2018.

⁶ [“Climate change: a threat to human wellbeing and health of the planet”](#) IPCC. February 28, 2022.

⁷ [“U.S. Heat Wave Frequency and Length Are Increasing”](#) U.S. Global Change Research Program. Accessed October 10, 2023.

⁸ Ibid.

⁹ Covert, et al. [“Climate change impacts on respiratory health: exposure, vulnerability, and risk”](#) *Physiological Reviews*. 103:4. October 2023.

2. Pursuing net-zero emissions can benefit economic growth by creating clean energy markets, economic resilience, and green jobs.

Investing in climate action not only mitigates risks but also presents significant economic opportunities, including job creation and sustainable growth. A report by the Global Commission on the Economy and Climate estimates that transitioning to a low-carbon economy could create 65 million new jobs globally by 2030, demonstrating the economic benefits of climate action.¹⁰ While it is true that only some of those jobs would be in the U.S., there would still be major benefits to the U.S. by way of a stronger global economy.

Pursuing net-zero emissions by 2050 does not have to come at the expense of economic growth. As the Organisation for Economic Co-operation and Development (OECD) stated in its 2017 report *Investing in Climate, Investing in Growth*, acting to address climate change “can generate inclusive economic growth in the short term, in addition to securing longer-term growth and well-being for all citizens.”¹¹ The OECD believes this strategy is compatible with sustainable 2% global economic growth.¹²

The net-zero emissions goal presents multiple economic opportunities. One area of economic opportunity is the creation of a global market for clean energy. The global market for clean energy technologies is rapidly expanding. Renewable energy sources, such as wind and solar power, are becoming increasingly cost-competitive with fossil fuels. This transition offers opportunities for innovation and market growth.

Another area of economic benefit to the net-zero goal is that it could create economic resilience. Climate change poses economic risks, including damage to infrastructure, supply chain disruptions, and increased insurance costs. Mitigating actions often include bringing production back to local regions. By taking proactive measures to reduce emissions and build resilience, economies can better withstand these challenges.

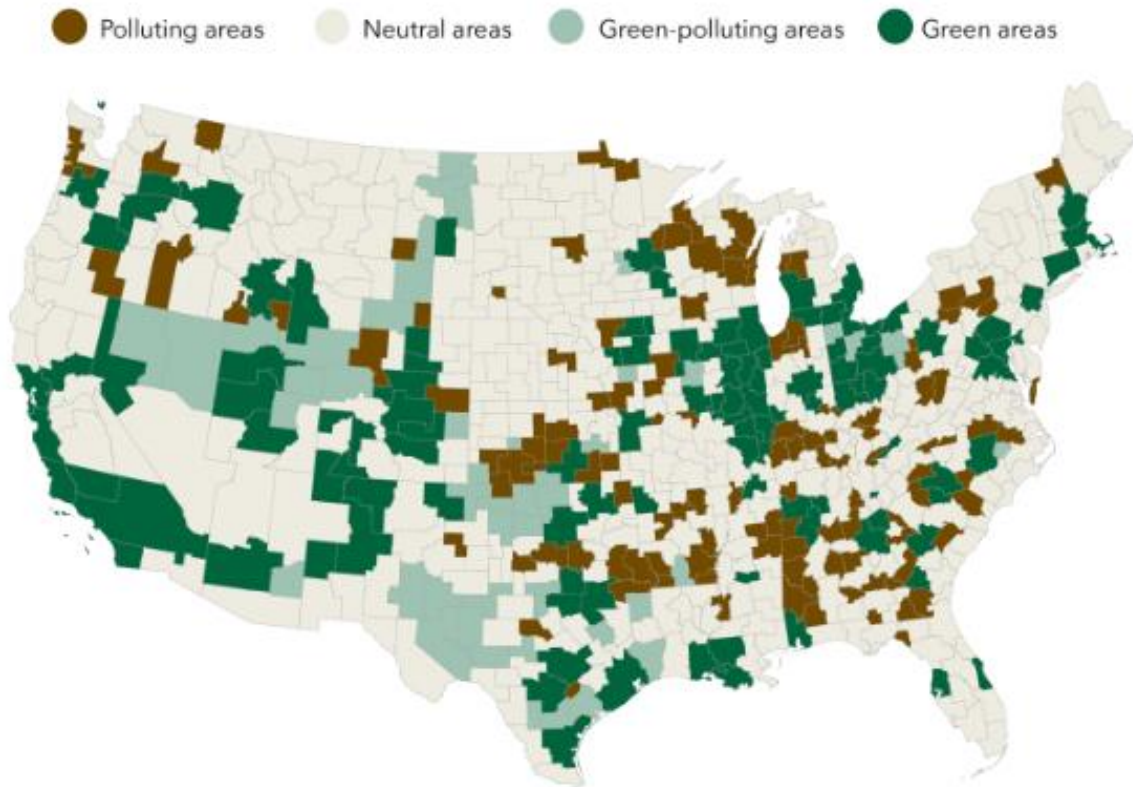
A third area of economic benefit is green job creation. The transition to a low-carbon economy requires investments in renewable energy, energy efficiency, sustainable agriculture, and other sectors. These investments create a wide range of jobs, from manufacturing and installation of solar panels to research and development of clean technologies. According to an analysis by the International Monetary Fund (IMF), U.S. labor markets are well-suited to transition from jobs in polluting industries (e.g., coal mining) to green jobs, without major disruptions to employment or average workers’ pay, in part because green jobs and polluting jobs are so closely collocated. See the map in Figure 1.

¹⁰ [“Climate Solutions”](#) Global Commission on the Economy and Climate Change. 2018.

¹¹ [“Investing in Climate, Investing in Growth”](#) OECD. 2017.

¹² Ibid.

Figure 1. Green Jobs and Polluting Jobs are in Close Proximity to One Another



Source: [International Monetary Fund](#). December 13, 2022.

This analysis of the U.S. labor market concluded that many areas that are rich in green-intensive employment “tend to either neighbor or overlap directly with pollution-intensive rich areas.” About 72 percent of commuting zones rich in pollution-intensive jobs are either also rich in green jobs or border a geographic area that is rich in green jobs.¹³ Transition would be feasible.

3. Committing to net-zero emissions by 2050 fosters technological innovation.

History shows that ambitious environmental goals have led to technological breakthroughs. For example, increased demand for electric vehicles (EVs) has spurred advancements in battery technology. Some of the most respected business leaders recognize that setting aggressive targets like net-zero emissions by 2050 can act as a catalyst for innovation. For instance, leading business consulting firm McKinsey & Co. advise their clients, “Building a net-zero world requires

¹³ [International Monetary Fund](#). December 13, 2022.

innovation in technology and business models, which will create growth opportunities for companies that take action.”¹⁴

The 2050 date for the Net-Zero goal makes the goal achievable because technological innovation takes time. LEDs and lithium ion batteries took between 10 to 30 years to go from the first prototype to the mass market.¹⁵ Many of the technologies we need to reach Net-Zero exist, but not all of them are ready. According to experts from the International Energy Agency, “Around 35% of the cumulative CO2 emissions reductions needed to shift to a sustainable path come from technologies currently at the prototype or demonstration phase. A further 40% of the reductions rely on technologies not yet commercially deployed on a mass-market scale.”¹⁶

Figure 2 shows how long experts predict it will take for various innovations to become fully viable and ready to be deployed broadly.

Figure 2. Climate Tech Readiness



Source: “[The Future of Climate Tech 2023](#)” Silicon Valley Bank. 2023.

¹⁴ “[Innovate to Net-Zero](#)” McKinsey & Co. Accessed October 6, 2023.

¹⁵ Gul, Pales, and Bennet. “[IEA Special Report on Clean Energy Innovation highlights the need for countries to work together to accelerate technology progress](#)” *Mission Innovation*. July 8, 2020.

¹⁶ Ibid.

To rise to the challenge, companies will invest in research and development (R&D) for clean energy technologies, energy efficiency measures, and sustainable practices. Research from BloombergNEF, a business analysis firm, estimates that to reach the global net-zero goal by 2050 represents a high-tech investment opportunity of almost \$200 trillion worldwide, or about \$7 trillion a year.¹⁷ Major tech investments need to happen, for instance, in carbon capture and storage technologies and advanced nuclear technologies. Ambitious emissions reduction targets will also lead to a bigger effort to be made in scaling up renewable energy sources such as wind, solar, and advanced energy storage systems.

Increased incentives for businesses and entrepreneurs to create and commercialize clean technologies might also come from government sources. For instance, the U.S. Department of Energy (DOE) has made available \$250 million in funding “to help Federal agencies implement net-zero building projects and set an example in sustainability as the nation works to transition to clean energy and combat climate change.”¹⁸ These investments will benefit the businesses and investors who rise to solve these technological challenges.

4. The goal of “Net-Zero by 2050” promotes global political cooperation in addressing climate change, fostering diplomacy and partnerships among nations.

The goal of Net-Zero by 2050 demonstrates the willingness of countries to collaborate on climate action and set common goals. With increasingly unstable geopolitical actors such as Russia, China, North Korea, and Iran on the world stage, the U.S. would benefit from collaborating with its friends and allies on an important goal such as climate change. The same international cooperation required to work together in addressing climate change could benefit the U.S. when other issues or concerns arise.

Productive cooperation is achieved in three main ways: shared responsibility, technology transfer, and through diplomacy and trust-building. Cooperation is achieved through shared responsibility because the goal of net-zero emissions recognizes that every nation must play a role in reducing greenhouse gas emissions. By setting a common target, countries can move beyond the blame game and focus on collaborative solutions.

Cooperation is also achieved through technology transfer. International cooperation encourages the sharing of clean energy technologies and best practices among nations. This technology transfer can accelerate emissions reductions in developing countries and promote sustainable development. Government involvement can create efficiencies in this area. For instance, research and development efforts that are supported by DOE Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards reduce the

¹⁷ [“The \\$7 Trillion Needed for Net Zero”](#) BloombergNEF. December 7, 2022.

¹⁸ [“Biden-Harris Administration Announces \\$250 Million for Federal Agencies to Advance Net-Zero Projects and Save Taxpayers Money”](#) U.S. Department of Energy. March 23, 2023.

financial risk to the recipient businesses, who do not have to risk their own capital, in exchange for the promise to share their achievements with fewer intellectual property restrictions on others.¹⁹

Lastly, cooperation comes from diplomacy and trust-building. Climate negotiations and agreements provide opportunities for diplomatic engagement and trust-building among nations. Working together on a global challenge like climate change can pave the way for cooperation on other international issues—even ones of security.

¹⁹ [“U.S. Department of Energy Announces \\$68 Million For Small Businesses Developing Technologies to Cut Emissions and Study Climate”](#) U.S. Department of Energy. February 22, 2023.

NEGATIVE ARGUMENTS

1. Achieving net-zero emissions will require switching to new technologies and energy sources that are more expensive than currently used technologies and energy sources.

Estimating the cost of pursuing the net-zero goal is not a straightforward calculation, but those who have tried it all agree that it will be expensive: trillions of dollars per year, with a total in the hundreds of trillions of dollars. One of the most frequently cited estimates comes from business consulting firm McKinsey & Co., who write: “Capital spending on physical assets for energy and land-use systems in the net-zero transition between 2021 and 2050 would amount to about \$275 trillion, or \$9.2 trillion per year on average, an annual increase of as much as \$3.5 trillion from today.”²⁰

Some analysts report that renewable energy sources are cheaper than fossil fuels.²¹ However, those analyses typically do not include the subsidies that renewable energy sources receive from the government, which runs in the billions of dollars. According to the Energy Information Administration (part of the U.S. government), U.S. subsidies for renewable energy producers more than doubled between 2016 and 2022, rising from \$7.4 billion to \$15.6 billion.²² Moreover, it is impossible to fully account for the unreliable nature of many renewable energy sources.²³ Solar energy depends on having sunny days. Wind energy depends on having windy days. Hydroelectric electricity can only be installed in certain locations where there are rivers and bodies of water nearby. They are not a true apples-to-apples comparison.²⁴

Whatever benefits that green energy sources might have in certain applications, fossil fuels are still a better overall technology because they are abundant, they are energy dense, and they are convenient. Coal, oil, and gas produce a lot of energy per unit of weight. Relatively small quantities of these fuels can do relatively large amounts of work or provide relatively large amounts of heat. Fossil fuels are in many ways responsible for our improved living standards over the past century. As a report from the Brookings Institution concedes,

“The world today is unrecognizable from that of the early 19th century, before fossil fuels came into wide use. Human health and welfare have improved markedly, and the global population has increased from 1 billion in 1800 to almost 8 billion today. The fossil

²⁰ [“The Net-Zero Transition: What it would cost, what it could bring”](#) McKinsey & Co., January 2022.

²¹ Allen, L. [“Green energy is cheaper than fossil fuels, a new study finds”](#) *Science News Explores*. January 20, 2023.

²² [“US doubles renewable subsidies to \\$15.6 billion in last seven years, EIA says”](#) Reuters. August 2, 2023.

²³ Epstein, A. [“The Irrefutable Case for a Fossil Future”](#) *EnergyNow*. September 5, 2022.

²⁴ Einhorn, S. “Climate Change: What They Rarely Teach in College” 2023. p125

fuel energy system is the lifeblood of the modern economy. Fossil fuels powered the industrial revolution, pulled millions out of poverty, and shaped the modern world.”²⁵

Transitioning away from fossil fuels to cleaner energy sources requires significant investments in infrastructure, technology upgrades, and retraining of the workforce. Someday green energy sources might be better and cheaper, at which point people will freely choose to switch to them. To force a transition before these technologies are ready by setting an overly ambitious public policy goal, is to incur unnecessary costs that will only strain government budgets and private businesses.

2. The timeline for achieving net-zero emissions is overly optimistic, as it requires significant advancements in technology and infrastructure that are impossible to predict.

Pursuing the net-zero by 2050 goal is technologically ambitious. The only way to imagine successful attainment of that goal without seriously disrupting our standard of living is to assume that *someone* will achieve some fairly major technological breakthroughs. But innovation cannot be predicted, and it should not be taken for granted.

Achieving net-zero emissions often relies on the widespread deployment of carbon capture and storage (CCS) technology to remove CO₂ from the atmosphere. However, CCS faces technical challenges, high costs, and regulatory obstacles that have hindered its progress. The deployment of CCS technology, which is crucial for achieving net-zero emissions, has been slow. Various versions of CCS have been in use commercially for 50 years, yet it still is not the transformational technology that proponents have made it out to be.²⁶ CCS technologies are not as good as we need them to be in order to achieve the net-zero goal. As the International Institute for Sustainable Development (IISD) admits, “The economic viability of CCS for the oil and gas sector continues to rely heavily on federal and provincial government financial support.”

CCS technologies are just one technological hurdle to the net-zero by 2050 goal. There are many more. For example, energy storage and grid upgrades are another area that will need significant advancements. Transitioning to renewable energy sources like wind and solar requires major innovations in energy storage technologies and significant upgrades to the electrical grid. These infrastructural changes are complex and can take longer than anticipated.

²⁵ Gross, S. “[Why are fossil fuels so hard to quit?](#)” Brookings Institution. June 2020.

²⁶ Cameron, et al. “[Why the Cost of Carbon Capture and Storage Remains Persistently High](#)” International Institute for Sustainable Development. September 7, 2023.

With such an ambitious goal, there are many networks of actors (individuals, private companies, and governments) who have to change how they interact. As economist Patrik Söderholm points out, “the development of, for instance, new carbon-free technologies may often require the establishment of new value chains hosting actors that have not necessarily interacted in the past; this necessitates a relatively long process that can alter society in several ways, e.g., through legal amendments, changed consumer behavior, distributional effects, infrastructure development and novel business models.”²⁷

3. Transitioning to net-zero emissions could exacerbate social inequalities, as the costs and benefits of climate action may not be distributed equitably.

The costs of pursuing this goal are not evenly spread out across the population. For example, workers in the fossil fuel industry and communities that depend on fossil fuels would bear most of the burden of change. The energy sector alone employs approximately 7.8 million Americans. Of that, only about 3.1 million jobs (41%) are considered “aligned with net-zero,” leaving about 4.7 million Americans employed in jobs deemed incompatible with net-zero goal.²⁸ Those workers would experience job losses and financial challenges disproportionately compared to other Americans.

The net-zero goal would also disproportionately harm low-income households, who would bear the brunt of the economic and environmental impacts of climate policies. Pursuing the goal would almost certainly entail policies like carbon taxes or regulations that increase the cost of fossil fuel-based energy and products. While these policies are intended to reduce emissions, they can disproportionately affect low-income households, as a larger share of their income goes toward energy and necessities. Put another way, it might be easy for a wealthy person to switch to an electric car by buying a new expensive vehicle from Tesla, but people with lower incomes who are stuck driving cheaper gasoline cars will be the ones who pay the carbon taxes.

The same point holds for other items like energy-efficient appliances. Energy-efficient appliances often have higher sticker prices, which even if they are cheaper to own in the long run, are more expensive to purchase upfront. This can create a divide where wealthier households benefit more from incentives and subsidies aimed at promoting clean technologies.

Attempts to correct disparities and bring about equity using government policy interventions often come up short. For instance, researchers studying clean energy incentives in the state of

²⁷ Söderholm, P. “[The green economy transition: the challenges of technological change for sustainability](#)” *Sustainable Earth*. 3:6. 2020.

²⁸ “[2022 U.S. Department of Energy Employment Report Fact Sheet](#)” U.S. Department of Energy.

Wisconsin found that rural customers received only \$2.75 in incentives per capita compared to non-rural customers, who received \$4.83 per capita.²⁹ Similarly, an analysis of 66 different programs in California found that energy efficiency incentive programs tended to result in low participation among populations that were low-income, non-white, or had not attained a college degree.³⁰

4. Relying on unproven technologies and strategies to achieve net-zero emissions by 2050 carries risks, as their effectiveness is uncertain.

Some of the proposed technological solutions for achieving net-zero emissions by 2050 are in the experimental stage and may not deliver the expected results. Even if these new technologies can be shown to be effective in the laboratory, they still must pass the test of scalability, and do so without serious negative side effects or unintended consequences. Thus, counting on unproven technologies to achieve net-zero emissions by 2050 is risky.

One example is large-scale direct air capture of CO₂. Capturing CO₂ from the open air (as opposed to concentrated gas from a flue pipe or chimney) is technologically possible, but it is not very feasible. Presently it is the most expensive way to capture carbon, and there is no guarantee that it will ever become affordable. According to the International Energy Agency (IEA), “Future capture cost estimates for DAC are wide-ranging and uncertain, reflecting the early stage of technology development, but are estimated at between \$125 and \$335 per tonne of CO₂ for a large-scale plant built today.”³¹ The IEA sounds a familiar note about subsidization: “[T]he potential for costs to fall to these levels will be strongly dependent on increased public and private support for innovation and deployment.”

Rather than setting an ambitious global public policy goal that will require government to make risky and uncertain investments in experimental climate change mitigation technologies, we should look at alternatives. For instance, it is possible that we might be better off placing our trust in improving the efficiency of ordinary technologies that consumers buy in free and non-centrally-planned market transactions. Improving technologies that go in the home, such as tankless water heaters, more energy-efficient building techniques, more efficient residential cooling units, home geothermal units, and even light bulbs and electronics is a different way to move forward.³²

²⁹ Amann, et al. “[Toward More Equitable Energy Efficiency Programs for Underserved Households](#)” ACEEE. May 2023.

³⁰ Ibid.

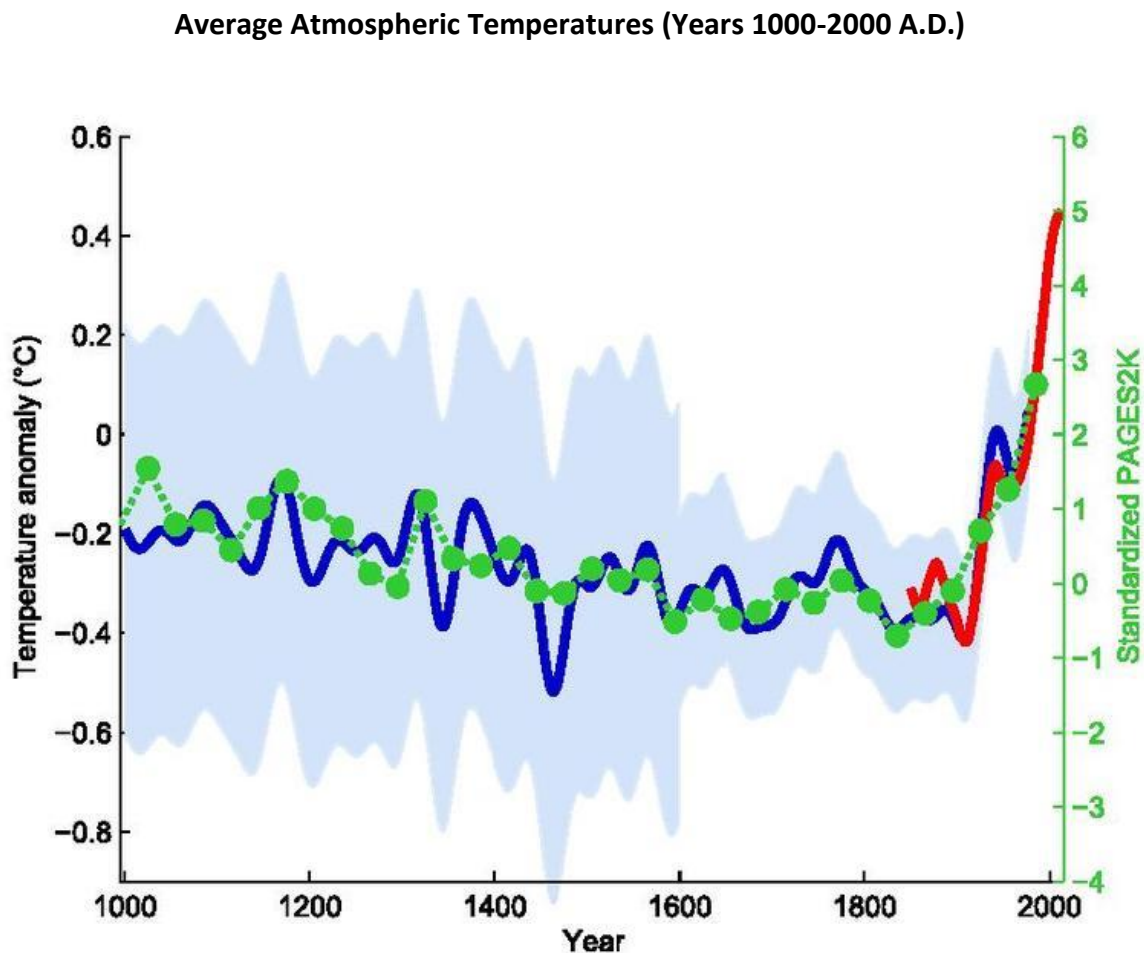
³¹ “[Direct Air Capture 2022](#)” IEA. 2022.

³² Einhorn, S. “Climate Change: What They Rarely Teach in College” 2023. p119

APPENDIX A. The Famous “Hockey Stick” Graph

You might have heard of the famous “hockey stick” graph before. The original graph is from a 1999 research paper that aimed to reconstruct temperature patterns in the northern hemisphere over the past millennium. The paper posited that up to that time, the 1990s was the warmest decade, and 1998 the warmest year. The blue and red lines are the estimates, and the background light blue area represents the margin of error. The green line shows the 2013 “PAGES2k” temperature reconstruction, which is a simulation based on a computer model that is intended to provide an overall corrected estimate of the temperature trendline.

It has been called a hockey stick shape because, the graph shows a long and relatively straight horizontal line, with a short but sharp change of direction, like a hockey stick lying on its side.

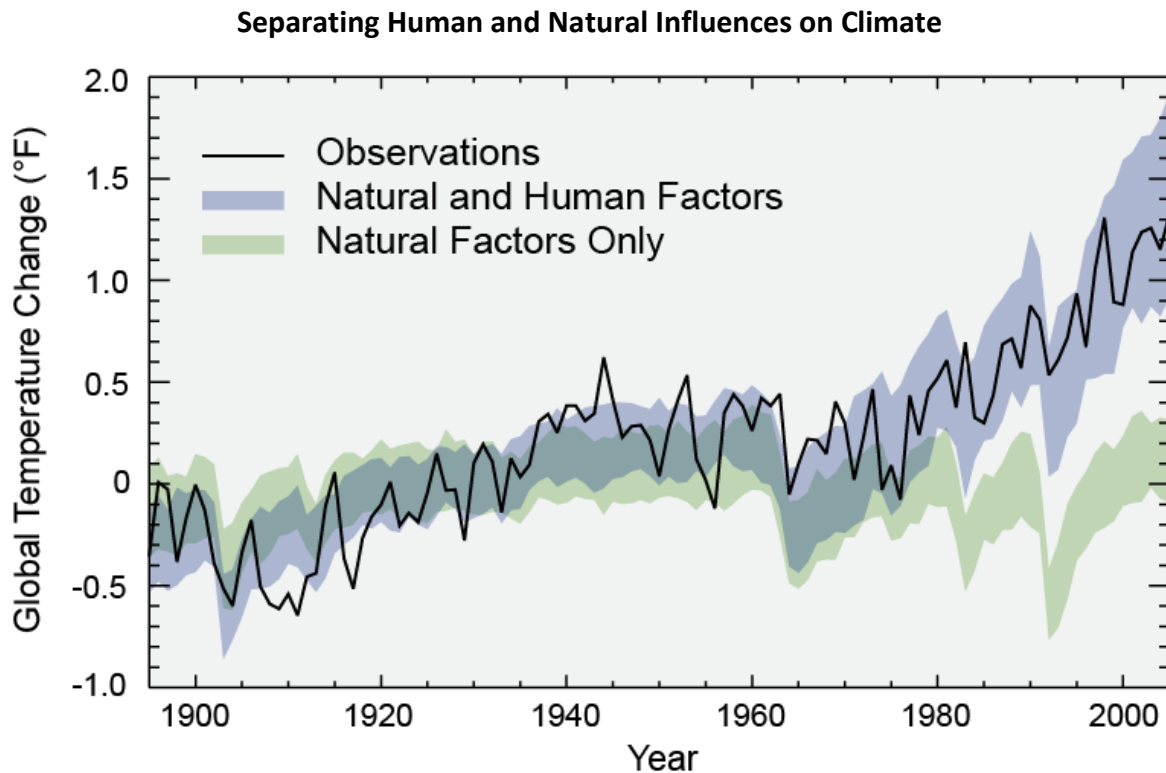


Source: Mann, Bradley, and Hughes. "[Northern hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations](#)" *Geophysical Research Letters*. 1999.

APPENDIX B. Natural Factors and Human Factors

There are different factors that contribute to climate change. Some are naturally occurring, whereas others are due to the activities of mankind. It can be difficult to disentangle the two contributing sources.

According to the United States Environmental Protection Agency, recent climate changes cannot be explained by natural causes alone. They argue that research indicates that natural causes do not explain most observed warming since the mid-20th century. They believe that it is likely that human activities have been the main cause of warming. This suggests a certain amount of reversibility—if humans are partly responsible for the warming by certain actions, then perhaps humans can reverse that trend by taking mitigating actions.



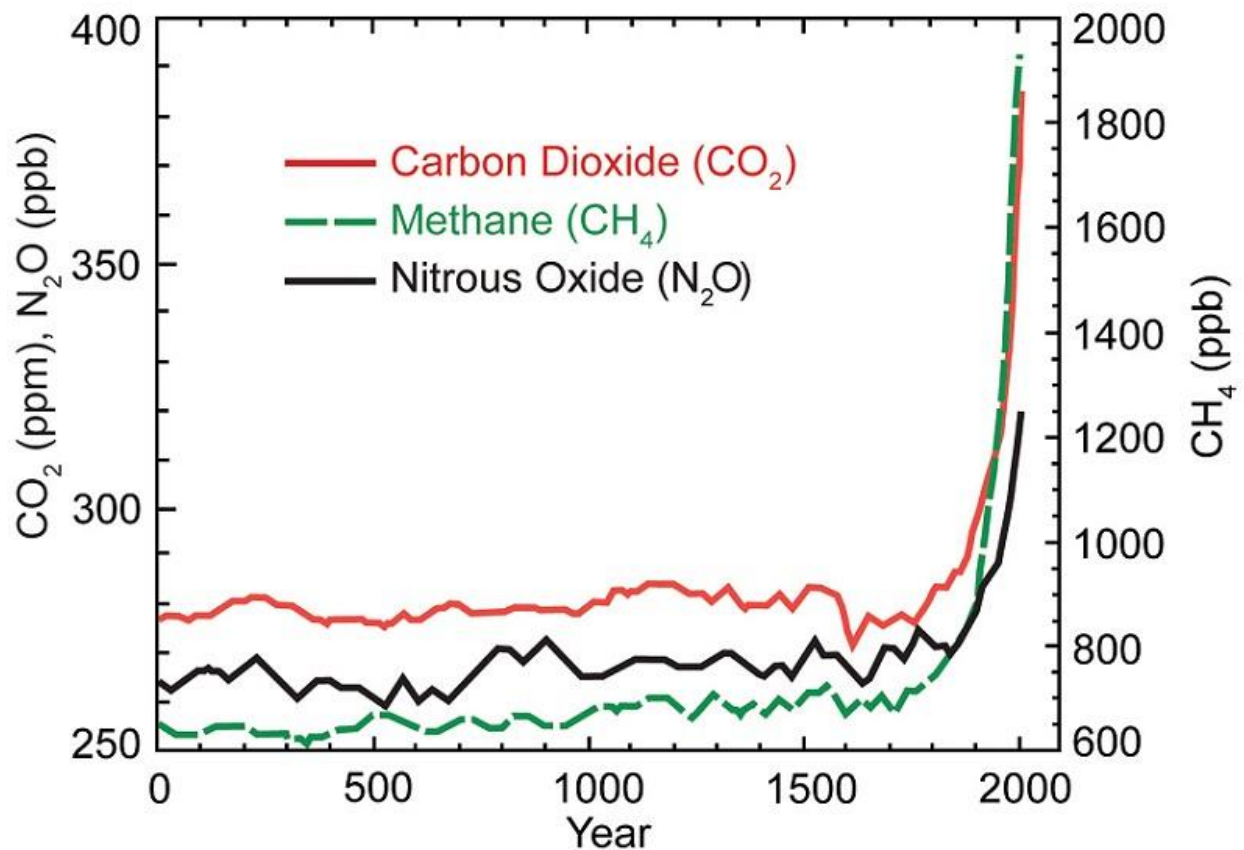
Source: [Causes of Climate Change](#). U.S. Environmental Protection Agency.
Accessed October 8, 2023.

APPENDIX C. Greenhouse Gas Concentrations Over the Past 2,000 Years

Many climate scientists believe that since the dawn of the Industrial Revolution around 1750, human activities have contributed substantially to climate change by adding greenhouse gases to the atmosphere. The graph below shows the atmospheric concentrations for three greenhouse gases (Carbon Dioxide, Methane, and Nitrous Oxide) over the past 2,000 years. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.

Atmospheric Concentrations

Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion molecules of air.

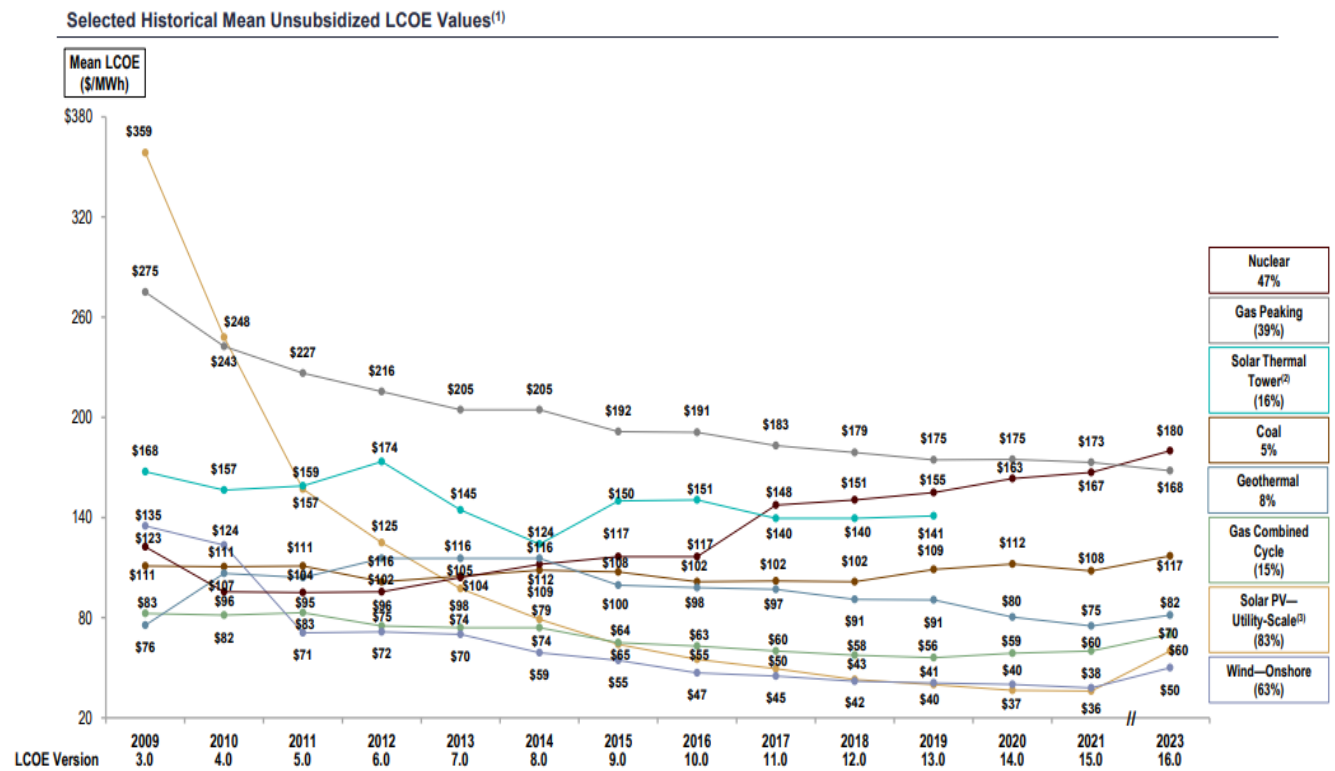


Source: [U.S. National Climate Assessment](#) (2014).

APPENDIX D. Cost of Various Energy Sources

Some energy sources are cheaper than others. The graph below shows the historical cost per megawatt hour of various energy sources, not including government subsidies.

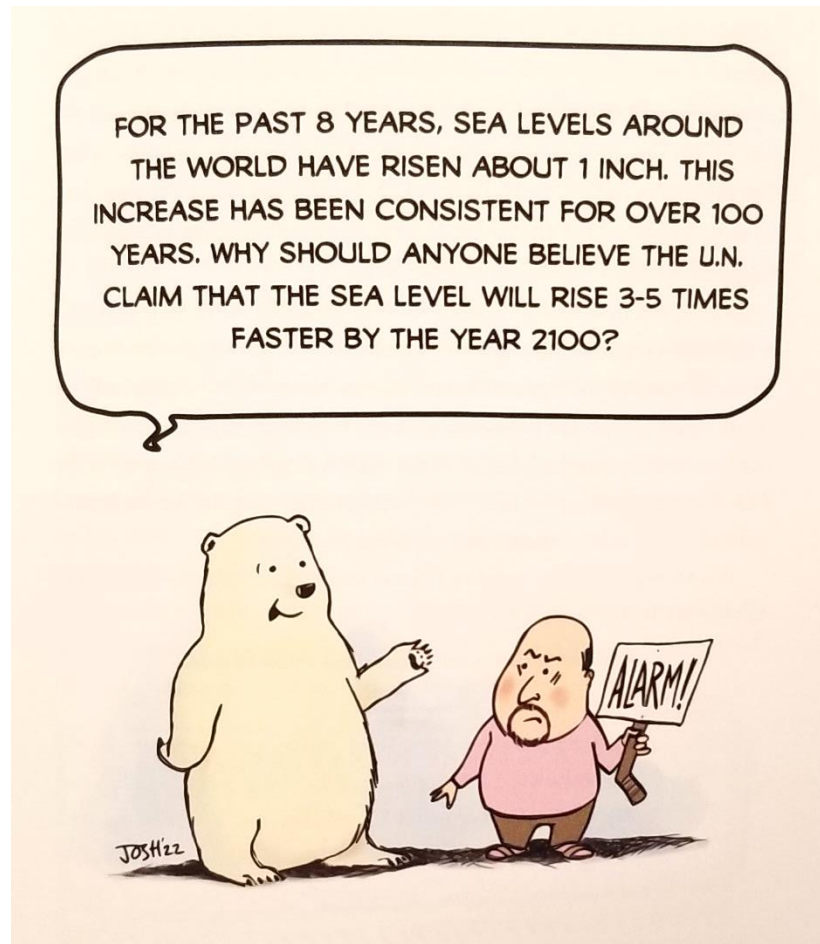
Levelized Cost of Energy Comparison 2009 to 2023



Source: [Lazard Levelized Cost of Energy Analysis](#). 2023.

APPENDIX E. Understanding Risks and Assessing Urgency

One of the trickiest parts about environmental policy is understanding the risks and weighing the predicted outcomes of action versus inaction. Proponents of the net-zero goal are concerned about changes to temperature, sea level, and other parts of our environment, but they often must make their case based on predictions and extrapolations from current trends. Justifying action is part of the burden for those who call for action. Political cartoons exist for both sides of the debate. The cartoon below, for example, questions whether fear about climate change is justified.



Source: Einhorn, S. "Climate Change: What They Rarely Teach in College" 2023. p39