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The Dark Side of Power: Shortcomings of America's Energy Grid and How to Fix Them

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Abstract

This paper examines the current state of the United States' electric grid and how constantly increasing energy demand requires an overhaul of the current system into one that is more interconnected, sustainable, and resilient. Chapter One uses quantitative data to explain the current problems with the United States' energy production, distribution, and usage. Chapter Two discusses the history of the electric grid and how consistently increasing energy demands have led to rapid innovation and expansion. This chapter will discuss changes the American energy industry over time and how key takeaways can be applied to proposed future advancements. Chapter Three addresses the economics surrounding the current state of the energy grid, including an analysis of current United States energy market structures and externality valuation techniques. It also includes an evaluation of the economic benefits of grid infrastructure advancement. Chapter Four focuses on the political background of changes to energy policy, including how politics have helped usher in energy transitions of the past. This chapter also includes discussion about the intersection of international politics and domestic energy production. In Chapter Five, the paper focuses on policy recommendations to encourage renewable energy expansion and to change the landscape of the United States' electric grid. Some of these suggestions include adopting Standard Market Design and rethinking federal energy jurisdiction to streamline essential grid infrastructure advancement projects.

Keywords: Energy transition, electric grid, sustainable energy, energy markets, energy policy, grid sustainability, grid modernization, Standard Market Design

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Introduction – "They Don't Understand It"

Early on in the process of writing this paper, I set up a very informal interview with a former boss of mine who works at a sustainable energy company. I needed to gather as many ideas and guidance as possible and having worked across the energy industry for almost 40 years, he seemed like the perfect person to ask. He did warn me that he was in the midst of a pretty busy week, so I should come ready to fire as many questions as possible as quickly as I could. My first question was fairly basic, one that I though could give me some insight into his views and shape the rest of our conversation. After a very brief introduction, I asked him, "What is the biggest misconception you think people have about the energy grid?"

"They don't understand it. At all."

His answer hung in the air for a second as I paused, hoping he would elaborate a little further about what he meant. He didn't. I gathered myself and moved onto the next question. Our fifteen-minute conversation ended up having more back and forth and longer winded responses, but when we were finished, his first answer was the one that stuck with me the most.

"They don't understand it. At all."

As I began gathering books and journal articles for this paper, I began to realize how true his statement was, and why it was so blunt. The way that we obtain, generate, transmit, and use energy is incredibly complex. There are federal and state laws at every turn, international sanctions that impact pricing, and intense levels of air, water, and land pollution involved with every step. When someone wakes up in the morning and turns their bedroom light on or goes to the fridge to take out their carton of eggs, I'm sure all of these complicated processes don't run through their head. I know they don't cross my mind.

But what happens if, one morning, your bedroom light doesn't turn on? What if you go into the kitchen only to find that your refrigerator has shut off and everything inside is now at risk of spoiling? Your life would practically some to a standstill.

Thankfully, with the exceptions of severe storms and natural disasters, our power in the United States rarely goes dark like this. But have you ever thought about where that power comes from, and why we can almost always count on it to be there for us? And what can we do make sure it stays that way?

With the importance that energy has for our livelihoods, it is a mystery why we don't understand much about it past the fact that we can control it with a switch, plug, or remote. The truths that lie past our appliances are not as clean as we might hope. Energy production is one of the world's largest polluters. Our energy grid is outdated, and power outages are becoming more common. Energy bills are constantly rising without much warning or reason.

This paper will help explain the severity of these problems, as well as many others. Chapter 1 provides quantitative data about the environmental impact of the energy industry, as well as laying out a brief roadmap of possible solutions. Chapters 2-4 will explain the history, economics, and politics of energy in the United States. In Chapter 5, I will explain policy recommendations that can transform the future of the energy landscape in the United States for the better.

By reading, I hope you will gain a more comprehensive understanding about what goes into the electricity that powers everything in your home. As the 21st century rolls forward, energy will become a more relevant topic, and I believe it is time for the average consumer to have a better understanding of our grid and what we can do to fix it.

Chapter 1 – How Energy Production Powers Climate Change

This chapter provides an in depth look at the value of the different kinds of ecosystem services, how their influence reaches all parts of the globe, and their importance to human society. One of the main ecosystem services that humans rely on is the climate, which is being rapidly deteriorated in a process known as climate change. Climate change is mainly caused by the emission of greenhouse gases, which are a major byproduct of energy generation and distribution. In order to slow the effects of climate change, there needs to be a rapid reduction in the levels of air pollution from the energy sector. Two ways to achieve this are by creating a national standard energy market and by constructing high-powered transmission lines across the country.

Energy Use, Climate Change and Ecosystem Services. As previously described, this thesis covers the current state of the American electric grid, the problems connected to energy generation and distribution, and the need to create a standard market to oversee all energy production in the United States. The need for an organizational change to the grid is a multifaceted problem. Its current arrangement is unreliable and wasteful, and the unnecessary pollution that it produces is a large contributor to air pollution and thus the acceleration of climate change in the United States. Environmental degradation is directly connected to the deterioration of ecosystem services, which are the benefits that wildlife ecosystems bring to humanity. Ecosystem services are divided into four categories: provisioning, regulating, cultural, and supporting.

Provisioning ecosystem services are the things that humans take from nature for their use, such as food, water, and fuel. Humans use this service for nutrients and to make the products that we use every day. All of the energy that humans use also comes from this division of ecosystem services, both nonrenewable and renewable forms of energy. The misuse of any of the resources provided by this service has consequences, such as the loss of biodiversity and the exhaustion of limited resources. Specifically relating to energy production, depleting the available nonrenewable energy sources that a country has can lead to rising energy costs as those resources become harder to find and more difficult to extract. Inefficiencies in the energy grid can also lead to the overconsumption of nonrenewable energy sources, which in turn increases the amount of air pollution a country emits (National Wildlife Federation, n.d.).

Regulating ecosystem services are the basic environmental provisions that allow for life on earth to thrive. The climate is the largest regulating ecosystem service, and climate change caused by human influences disrupts all of the balance provided by regulating ecosystem services. Some of the other services provided by regulating ecosystem services are flood and erosion control, disease prevention, and pollination. When the effects of climate change impact regulating ecosystem services, the costs can be extremely detrimental to local communities. If an increase in temperature leads to a decrease in pollination and disease prevention, crop yields can decrease and cause food shortages in local communities. While people may not often see these services as essential, their presence and upkeep are essential to the survival of human life across the world.

Cultural ecosystem services are the intangible benefits that come from having a healthy ecosystem to live within. These can be described as the intersection of the natural world with art, literature, religion, spirituality, and mental well-being. A person's ability to take their dog for a walk in a healthy park is a cultural ecosystem service – if the effects of climate change impact the color of the grass in the park or the number of flowers in bloom, it could have a detrimental impact on a person's well-being. Cultural ecosystem services are also the backbone of eco-tourism, which is largely based on the aesthetic values of different environments that have become large tourist destinations. If climate change takes away the natural beauty of things like waterfalls or coral reefs, it would also cause the collapse of a large global industry that depends on the health of these environments.

Finally, supporting ecosystem services are the fundamental processes that allow for life on Earth to survive, such as photosynthesis and the water cycle. They are largely unseen yet completely necessary aspects of our natural environment that we need to survive. Disruptions to these services from climate change end up impacting all other life on earth by depriving us of basic natural processes, like decomposition.

These ecosystems services are all completely necessary functions that our natural environment provides, whether they are seen or unseen. Unfortunately, the effects of climate change have been shown to have detrimental impacts to all of these services. The later sections in this chapter will explain further the effects of climate change on ecosystem services and how current trends in energy usage contribute to it. By completely understanding the effects of climate change and the role that energy production plays in it, it will become clear why such strong changes are needed to the ways that we produce, distribute, and use energy in the United States.

Environmental Degradation Caused by Power Generation. The term "climate change" refers to the long-term shifts in global temperature and weather patterns that is primarily driven by human activities, namely the emissions caused by the burning of fossil fuels like coal, oil, and gas. The climate is a regulating ecosystem service, and its steady change has caused detrimental consequences for all life on Earth. One of the most reported effects of climate change is the gradual rising of global temperatures, which is usually referred to as global warming. Hotter summers and melting ice caps are some direct consequences of this increased average temperature, but the effects of climate change go well past the consequences directly related to heat.

Changes to a region's average temperature causes increasingly frequent abnormalities in its weather patterns, especially with extreme weather events. Natural disasters such as major hurricanes, floods, droughts, and wildfires that used to be thought of as once-in-a-lifetime events are worsening almost yearly across the world. The damages of these events total billions of dollars every year in the United States alone, not to mention the many lives lost across the world to these disasters. Slower changes to weather patterns such as decreasing precipitation or unusually short growing seasons can also gradually erode at livestock and food supplies, changing the growth potential of communities in the developing world.

These weather events and natural disasters also put a strain on the United States' energy grid, sometimes causing blackouts or brownouts when production or transmission capabilities are harmed by the storm. One of the most famous examples of this was the Texas winter storm of 2021 which caused blackouts across the state following an unprecedented cold spell. When communities lose power for extended periods of time, it can lead to massive economic losses and even deaths. Increasing grid stability to be prepared for harmful weather events is a common theme among the solutions that will be proposed later in this paper as it can help mitigate some of the losses that inevitably result from natural disasters.

All of these effects are a direct result of climate change, which is caused by the combustion of harmful fuels releasing pollutants that trap heat inside the Earth's atmosphere, causing the planet's temperature to rise unnaturally. The main culprits of this warming effect are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as numerous other gases (Environmental Protection Agency, n.d.). These compounds are commonly known as greenhouse gases (GHGs). The fuels that the United States uses for electricity are major contributors to the advancement of global warming and climate change. The combustion of all fossil fuels releases at least some amount of greenhouse gases.

Every country in the world is partially responsible for the emission of greenhouse gases. The United States currently accounts for 15% of the world's greenhouse gas emissions, second only to China, who is responsible for 31%. Historically, however, the United States has emitted 25% of the world's all-time greenhouse gases, which is the most of any country (Union of Concerned Scientists, 2023). Energy-related pollution makes up the vast majority of greenhouse gas emissions across the world. Industrial, commercial, and residential energy production and use accounts for 41.7% of worldwide greenhouse gas emissions, with transportation in a distant second at 16.2% (Ritchie and Roser 2023).

In the United States, these numbers are similar, with energy-related emissions in generation, industrial use and commercial use causing 66% of emissions and transportation causing 29% (Environmental Protection Agency, n.d.). These energy-related emissions include both the generation of the electric power as well as the emissions caused by its use in factories, homes, and businesses. When looking more closely at the sources of these emissions, the energy sector itself can be separated from the homes and businesses that are using the energy it provides. The "energy sector" refers to the emissions that result from the transformation of raw fuel into usable electric power, including its extraction, combustion, transmission, and distribution. In other words, this could be seen as the power that is used to make the electricity that we use every day.

Emissions from the energy sector can be partially separated into two categories: fuel production and energy generation. Fuel production applies to the location and extraction of fossil fuel reserves, which are then converted into usable forms; these activities include oil and natural gas extraction, refineries, and mines. This does not account for much of the energy sector's pollution. The main culprit is power generation, which is the combustion of fuels in power plants to create electricity, which is then distributed for residential and commercial use. Power generation accounts for the "vast majority" of greenhouse gas pollutants from the energy sector and 95% of the yearly damages caused by air pollution from energy (Paulina and Muller 2016, 204-206).

Human society pays a steep environmental price for the way it produces and uses its energy, but another problem comes with the amount of usable energy that is wasted or lost on its journey from fuel to electricity. The power plants that combust fuels to generate electricity tend to be relatively far away from the homes and businesses that need it. Electrical grid is used to distribute this energy, but outdated power lines and inefficient equipment mean that a percentage of this energy goes unutilized – it could be burned off as heat during transmission or perhaps used to power an appliance that doesn't need to be drawing power at that time. Studies vary on the exact amount of energy lost as waste every year, but it is a fact that we are wasting a very sizable amount of energy. And because most of this energy comes from the burning of climate change causing fossil fuels, it means that we are advancing climate change without actually getting any societal benefits from our actions. The avoidance of these damages is one of the major reasons why our energy sector needs a complete overhaul.

The damages caused by the combustion of fossil fuels for energy use manifest themselves in many ways, including the acceleration of climate change and human health impacts (Environmental Protection Agency, n.d.). The deterioration of the climate, which is a regulating ecosystem service, has a detrimental impact to all organic life on Earth. As previously mentioned, humans depend on consistent weather patterns for predictable crop yields, clean air quality to maintain healthy respiratory systems, and low rates of natural disasters to protect our livelihoods. As the climate changes and becomes more unpredictable, it will have an impact on all parts of human society. This is why it is important to recognize the severity of this issue and work to find solutions before it is too late for our planet.

Power Generation for a New Generation. It is undeniable that energy generation and distribution is a major contributor to the emission of air pollutants in the United States, and thus, is a key player in our nations' role in the advancement of climate change. Also, American energy demand is not decreasing. While the year over year growth in energy demand has slowed since the turn of the 21st century, the US population is still steadily increasing, and a bigger population will inevitably require more power (Environmental Protection Agency, n.d.). As previously explained, the current way that the United States currently produces its energy is neither sustainable nor acceptable in a world where decreasing emissions has become an international priority.

Increasing the efficiency of the American grid and lowering the pollution that comes from energy generation is not a simple fix. There are plenty of clean energy sources and demand reducing techniques that can help solve this problem, but in order to actually cut on emissions and increase reliability, every technique needs to be used together. There is not one single technology that will save the grid, and a complete switch to renewable energy is not feasible given the current political landscape and physical construction of the grid. In order to provide the opportunity for this problem to be solved, we need to implement the framework for innovation to flourish. This manifests itself in two major solutions: standard market design and a completely interconnected grid.

Standard market design is a proposed change to the structure, mechanisms, and regulations governing wholesale electricity markets which would promote efficiency and competition. It establishes universal rules for market participants, including generators, transmission operators, and distributors, which would ensure fairness and transparency. It would also address grid management issues like congestion management and reliability through competition and homogeneity. Standard market design also includes provisions for the expansion of renewable energy usage and demand response programs, which would aim to deliver reliable and affordable electricity to consumers while fostering a competitive market environment. In order to see meaningful and efficient change, the entire country needs to play by the same rules that foster innovation and sustainable solutions.

These solutions will all work hand-in-hand to decrease reliance on fossil fuels, increase grid reliability and efficiency, lower emissions from power generation and lower costs to consumers. One way is by creating a platform for energy innovation. Currently, the United States energy grid is fragmented by both regions and states, making it difficult for new technologies to emerge in places where legislation is strict – different energy system operators have different rules. This means that while one region may welcome a new technology to decrease energy demand, another may refuse it.

This is partially due to the mismatch of energy markets in the United States. There are primarily two kinds of energy markets – regulated and deregulated. Deregulated markets allow for market participants to own power plants and transmission lines, which also allows for customers to choose their own electricity provider and energy source. On the other hand, regulated markets are controlled by a vertically integrated monopoly that oversees the entire process of energy generation and distribution. The more intricate differences between these markets and their benefits will be discussed further in Chapter 3. The main point is that having a collage of different markets that each take up portions of different states and regions is an inefficient way to manage and change the ways that the United States uses energy. Having a singular type of market that expands over the entire energy grid would be a much easier way to expand innovative solutions for the ways we use energy.

The fragmented nature of the United States' energy markets also means that the country lacks a singular body that could oversee these changes in a focused and efficient way. The United States Department of Energy (DOE) is the federal agency that is responsible for securing and maintaining the country's energy security through research and innovation. However, they do not have a dedicated organization that could be tasked with enforcing any country-wide changes to market design or infrastructure advancements. The Federal Energy Regulatory Commission (FERC) is the part of the DOE which would currently handle these responsibilities, but their influence is mainly concerning interstate energy transmission and commerce. While this is essential to ensuring that different energy markets can work together, their power would need to be either expanded or enveloped by a more powerful organization that could quickly approve new projects and usher in an energy transition.

Creating a standard energy market with a national regulation body is not a revolutionary idea. It would act similar to how the Federal Aviation Administration (FAA) oversees all civil aviation, or how the Federal Highway Administration (FHA) manages interstate highways at both a national, state, and local level. The creation of such an organization would serve as a foundation for innovation and change to our energy grid. This idea will be discussed further in Chapter 5.

Increasing the platform for new technologies to save on energy will lead to a reduction in energy emissions. But the most important way to reduce energy emissions is by transitioning to renewable sources of energy. One of the major problems with renewable energy adoption in the United States is its transmission. Fossil fuel power plants have historically been built where they are needed, which saves on transmission costs to areas with high population density. The most reliable renewable energy generation tends to be concentrated in areas that cannot take advantage of the abundant energy, such as large-scale solar farms in the deserts of the southwest and wind farms on the plains or on top of mountains. A solution to this problem is creating a network of high-powered and long-distance energy transmission lines that have the ability to transport energy from where it is produced to where it is needed, even if it lies thousands of miles away. This will help reduce the need for high emission fossil fuel plants that remain in use because of their proximity to areas of high demand.

To revamp the energy industry, there is not a single solution that checks every metaphorical box. Society needs an "all of the above" approach where every solution that will pollute less and generate more energy is given a fair chance to capture a share of the market in America. For this to happen, lawmakers must provide the platform for these solutions to take hold, and the two most important things that must happen are the creation of a standard energy market in the United States and the construction of long-distance transmission lines to areas of high population across the country.

Chapter 2 – History of Electricity in the United States

Every fuel that humans have used since the beginning of time, from wood to coal to natural gas to wind, has been a product of their natural environment. Understanding the ways that these fuels have changed over time and the motivation behind these changes can provide insight into the history of our relationship with the natural world as well as a roadmap for changes coming in the future. Our use of energy, while essential for society to function, has also caused a great deal of harm to our planet because of the historical reliance on heavily polluting fossil fuels to power our society. As this problem becomes more and more apparent, it is crucial to look back to the processes and methods that brought us to this point in our relationship with energy. If our society wants to create meaningful change in our future energy use, consulting environmental history can provide an "essential" perspective that can help us avoid the mistakes of the past as well as show us the forces that have driven previous energy transitions (Hughes 2016, 135).

U.S. Energy Sources over Time. The sources of energy that the United States has used to produce its electricity have constantly changed since the country's founding. According to the U.S. Energy Information Administration, the United States currently gets its electricity from a mix of four major sources: natural gas (40%), coal (20%), nuclear (20%) and renewable energy sources (20%). These current percentages are products of government regulation as well as energy sector innovations that have made certain fuels more popular over time, while others have subsequently decreased in their usage rate. The idea of 100% renewable energy generation has become much more popular in recent years, but if society is going to move any closer to this goal, it is important to analyze the historical trends and that led to energy transitions in the past. In the United States, changes in energy sources have been a product of three factors – the new fuel became cheaper and burned more efficiently than its predecessor as well as being available in an abundant supply.

From the time of the first settlers in what would become the United States, wood was the primary fuel of choice. It was available in abundant supply and did not require much effort to find. The only other energy source used in this period was hydropower, albeit to a much smaller extent than wood. These two energy sources combined to power all of America in the 18th century and beforehand, up until the boom of the coal industry in the 19th century. Coal mines began a period of rapid growth in the United States in the 19th century, with the industry doubling or tripling in size almost every decade in the 1800s (U.S. Bureau of the Census. 1960, 450). The major tipping point came in 1876, when coal overtook wood as the majority energy provider for the United States, the first time in history where a fossil fuel became more popular than a renewable energy source.

The industrial revolution can be seen as one of the driving factors behind the adoption of coal as the United States needed a high-efficiency fuel to power its rapidly growing industrial sector. Coal is much more energy dense than wood as it contains about twice as many British Thermal Units (BTUs) of heat per pound, meaning coal burns much hotter than wood does. Also, from 1830 to 1870, the price for a ton of coal fell by over 50%, meaning that it became much cheaper for homes to begin using coal instead of wood, especially because it was twice as efficient as its predecessor (Adams 2013, 20-80). By 1925 coal accounted for about 80% of energy usage in the United States, a vast majority of which came from the new demand for electricity across the country (U.S. Bureau of the Census 1960, 450).

The advent of coal was also brought on by the expansion of railway lines across the country. Trains were able to efficiently transport coal from mining towns to major cities, encouraging them to transition to this newly available and more efficient fuel. This expanded access increased demand, which led to rapid expansion of the coal industry throughout the 19th century.

The next energy transition in the United States came from the switch from coal to natural gas. Historically, use of natural gas has been limited due to transportation limitations – pipelines were too unreliable to transport large quantities of fuel to areas of high demand. Coal did not have this problem, as the United States' extensive system of roadways allowed for its cheap transport. However, in the late 1800s, natural gas pipeline technology improved rapidly due to new welding techniques that made transportation much easier. The invention of the Bunsen Burner in 1885 also created a pathway for the safe use of natural gas, leading to growth of the industry in the shadow of coal in the early 1900s (Herbert 1992, 15-78). Much as the industrial revolution helped usher in the age of coal, the Clean Air Act helped emphasize natural gas as the fuel of the future. Natural gas emits much less carbon dioxide than coal, and new emission regulations on the coal industry led to increased costs. Natural gas, with its abundant supply, reliable transportation, low cost, and safe burning techniques rose to take the place of coal as the primary American fuel in the 21st century.

Alongside the rise of natural gas came the rise of nuclear power. Following the use of nuclear power in submarines during World War 2, companies began developing ways to harness nuclear power for commercial and residential use. According to the Energy Information

Administration, the first nuclear power plant opened in 1957 and new units were rapidly commissioned throughout the following decades. However, the nuclear disasters at Three Mile Island in Pennsylvania and Chernobyl in Ukraine during the 1980s drastically impacted public support for nuclear power, and new reactors afterwards were commissioned at a much slower rate. Today, nuclear power is much safer and represents the United States largest non-fossil fuel energy source. Nuclear power will play an important part in fulfilling demand if the United States is to transition away from fossil fuels, but with high costs for new plants and varying public support, it seems unlikely that its share of the market will grow any larger than what is has been for the last twenty-five years.

Today, much emphasis is placed on a third energy transition, this time from fossil fuels to renewable energy sources. Favorable regulation and increased public opinion have seen the industry's size increase rapidly in the 21st century, yet the United States still uses as much coal as it does all renewable energy sources combined. By examining what needed to happen for the first two transitions to occur, there is a framework for renewable energy to follow in order for it to become the United States' leading energy source. Renewable energy needs to be cheaper than fossil fuels, as close in efficiency as possible and made easily accessible via generators or transmission lines across the country.

The Grid from Edison to The Present. Although the coal industry saw massive growth throughout the 1800s, its true potential for electricity generation was not fully realized until the tail end of the century. In 1882, Thomas Edison opened the Pearl Street Power Station in New York City, the first centralized power plant in the United States. It used coal powered steam engines to supply electricity to a few hundred customers in lower Manhattan, which was revolutionary at the time (Dyer 1992). Now, however, the United States has expanded to over 331 million people, all of whom need the ability to access electricity in some form. According to the U.S. Energy Information Administration, this feat requires about 11,000 power plants and 160,000 miles of power lines. This took decades of innovation, and looking into this original construction and expansion of the grid can provide an insight into how it can be changed in the future.

The techniques used by Edison in 1882 could only transport energy a few miles away, making it necessary for power stations to be located downtown in major cities to serve the largest customer base (Dyer 1992). Power stations began to appear in major cities across the United States by the turn of the 20th century, with electricity transmission lines cluttering the airspace above sidewalks and roadways (Wuebben 2019, 52). By 1915, every major city in the United States had at least one power plant within its city limits (Wuebben 2019, 58). These single city micro-grids were the first example of the way that the nationwide energy grid would eventually take shape, with power stations located in optimal locations in order to serve as many customers as possible.

The biggest shortcoming of this system was the distance energy could travel, but developments were already in progress. In 1896, a hydroelectric plant at Niagara Falls powered streetlamps in Buffalo, New York using 20 miles of underground cable. After this discovery, scientists experimented with running an electric current from Niagara Falls over 400 miles to New York City via a telegraph wire. The current received in New York City was extremely weak, but the experiment showed that there was a feasible pathway to the creation of efficient long distance transmission lines (Gawronski 2004, 8-68). Engineers began construction of power lines to provide a strong connection from Niagara Falls to New York City, ushering in a new wave of innovation centered around transporting electricity over long distances (Gawronski 2004, 80).

In 1900, as transmission experiments and constructions were still in their infancy, only 5% of non-rural households had access to electricity. Almost all of these homes were located in major cities and were within a short radius of a power station. By 1930, this number had climbed to 85% thanks to innovative technologies involving electricity transmission as well as the construction of new power plants across the country (Lewis and Severnini 2020). These new power plants were being built in increasingly rural areas thanks to drastic improvements in transmission technology – in only 20 years from 1900 to 1920, maximum transmission voltage increased by 200% (Casazza 1993, 10). This also meant that power plants could be built in much more desirable locations. Coal plants, for example, require large quantities of water for daily operations. Increased transmission capabilities meant coal plants could be built much closer to sources of water, leading to increases in size and efficiency of coal power plants (Hughes 1993, 370).

The result of this innovation explosion was the construction of over 600 new large-scale power plants from 1930-1960 (Joshua and Severnini 2020, 2). By the 1960s, America's grid had finally taken its shape with the capacity to transmit electricity to almost every citizen. To increase reliability, transmission lines were interconnected to different power plants which created a coast-to-coast network of energy transmission sources and their distribution networks. In 1967, for a short time, the United States' grid was completely interconnected so that a power plant in Boston could power a lightbulb in California (Cohn 2019, 239-242). Although this experiment was abandoned due to technical challenges, it laid the groundwork for the notion that our grid should be as interconnected as scientifically possible. By this point the United States had finally become confident in its energy reliability, but international unrest would soon end this period of rapid innovation and begin a new era of uncertainty for the energy sector in the United States.

The 1970s. In the first seventy years of the twentieth century, the United States' electricity and energy use grew dramatically. In 1900, homes and businesses were primarily heated by coal, and horse-drawn carriages dominated the transportation industry. By 1970, the United States had completely modernized thanks to rapid innovation in the ways that the country generated and distributed energy. However, the 1970s began a new age of energy use in which the United States became very aware of the ways that international conflicts can impact our domestic energy use as well as the environmental impact of our most popular fuel sources.

As the United States continued to industrialize and require more and more energy to keep up with its rapid growth, it began to rely heavily on the import of fossil fuels from other nations. Almost all of this came from the middle east – in 1972, 83% of the United States' foreign oil imports came from middle eastern countries (Lacey 1981, 415). Reliance on other countries for fuel sources had never been a problem for the United States, until 1973 with the world's first Oil Crisis. In 1973, the Organization of Arab Petroleum Exporting Countries (OAPEC) announced oil embargos on major nations, including the United States, which saw the price of oil triple across the world. The United States saw the price of oil rise from $4.31 to $10.11 per barrel in just one year, prompting restrictions on buying gasoline and using excess energy across the country (Wulfinghoff 2000, 18).

This crisis – as well as a second one in 1979 following the Iranian Revolution – had its biggest impacts on the transportation industry since relatively little oil is used in the production of electricity in the United States. However, national concern about sudden spikes in the price of fuel, reliance on other nations, and the uncertain future of fossil fuels were all introduced to the public sphere thanks to these two crises (Grossmann 2013, 2). The American public became conscious to the fact that fuel and energy were absolutely essential to their daily lives, and being at the mercy of other nations for its production meant that we were at risk of these crises happening more often. The public also became aware of the limited nature of fossil fuels, and a growing environmentalism movement across the world helped remind people that our fossil fuel usage comes with worldwide consequences. Fuel sources and energy use had quickly transformed from an individual choice to a "societal issue" (Wulfinghoff 2000, 3).

President Richard Nixon attempted to restore faith in the United States' ability to provide consistent and affordable energy for its citizens with "Project Independence" in 1973. This plan for energy independence aimed for the United States to achieve complete energy self-sustainability through energy conservation and efficiency as well as the increased use of renewable energy resources (Nixon 1973). The promises made by Nixon's administration were too far-fetched to actually serve as the framework for a feasible energy transition, but it did serve as one of the turning points for an era of American concern over our energy usage (Grossmann 2013, 15-90).

After Nixon left office in 1974, the remaining years of the decade still saw progress made in the American energy sector; the nation continued to be worried about the prospect of foreign influence over energy usage and the environmentalism movement continued to grow. Gerald Ford and Jimmy Carter continued to pass Acts and form governmental organizations that focused on American energy independence. The Energy Policy and Conservation Act of 1975 set the first ever fuel and energy efficiency standards for appliances in the United States (US Congress

1975). A year later, the Energy Conservation and Production Act of 1976 created economic incentives for the adoption and expansion of renewable energy. For the first time ever, it was clear that you could save money by using less energy or by prioritizing renewable energy (US Congress 1976). Overall, the 1970s completely changed the ways Americans thought about and used energy – all of the changes and innovations in the years since can be traced back to the changes in mindset that resulted from this important decade.

The Rise of Renewables. Perhaps the most important realization that resulted from the energy sector changes of the 1970s was that Americans noticed that fossil fuels were not completely reliable. As a fuel they are extremely efficient, but reliance on foreign powers for imports as well as their limited supply and environmental impact meant that alternative sources would be a welcome change for the public. Unfortunately, the renewables movement in the United States often only gains momentum in times of need, such as during the oil crises of the 1970s. The 1980s and 1990s saw relatively stationary and affordable fuel prices. This led to stagnation in the development of renewable energy technologies in the United States during these decades (McElroy 2009, 180).

A light at the end of this tunnel appeared in 1992. United Nations Framework Convention on Climate Change (UNFCCC) introduced an agreement in which participating countries pledged to reduce their greenhouse gas emissions to help combat the effects of climate change (United Nations 1992). While there was much to be desired from an environmentalism standpoint, this legislation did lead to an increased interest in future international commitments to usher in an energy transition, such as the Kyoto Protocol in 1997. While the United States did not sign the UNFCCC, they did pass the Energy Policy Act of 1992, which set new laws to increase clean energy use and improve energy efficiency use in the United States; Title XII of this act specifically created government funded incentives for the expansion of renewable energy usage (U.S. Congress 1992). These new policies did little by themselves, but they did signal a shift that renewable energy research would no longer remain a rainy-day activity only to be called upon in times of high fossil fuel prices or international pressure.

Since 1992, the renewable energy industry has seen consistent progress. In 1990, according to historical data from the United States Department of Energy, renewable energy accounted for 9% of United States energy production whereas today it has grown to over 20%. Almost all of this growth has come in wind and solar energies which combined to generate 30 times more hours of energy in 2016 than they did in 2000 (Benoit 2018). This can be attributed to the massive increases in research and development spending within the renewable energy sector – adjusted for inflation, average per year spending has increased by 73% from the 1990s to the 2010s (McElroy 2009, 40). Much progress has been centered in the recent years of the 21st century, but it could not have been done without the groundwork laid out in the 1970s and 1990s. As more and more favorable legislation is passed and technologies become more efficient, the renewable energy sector will continue to grow rapidly in the United States, and its expansion is crucial to the energy transition and the fight against climate change.

Chapter 3 – Energy Economics in the United States

While the United States economy is primarily concerned with consistent growth in terms of dollars and cents, the real backbone of all exchanges of goods or services is the natural environment. The services provided by our environment, from the water and soil used in agriculture to the air quality that allows for human life to thrive, all allow for our world's economies to succeed. Environmental economics is a discipline of economics that relates to the ways that these natural resources are used and protected as well as how their limited availability relates to the prices of goods and services. The energy industry is an integral part of this field, as the opportunities and shortcomings within the energy sector require a careful balance between economic growth and environmental sustainability (Thampapillai and Ruth, 2019).

As previously explained, it has become evident that our reliance on fossil fuels has posed environmental challenges. These include a reduction in our air quality, the advancement of climate change, and the finite nature of these resources, just to name a few. Consequently, the transition towards renewable energy sources has emerged not just as an environmental necessity, but as an economic opportunity. This chapter will examine the way energy is distributed in different types of economic systems across the country as well as the ways that environmental externalities can be measured and priced into activities that produce pollution. It will close with an examination of economic drivers of the energy transition and the opportunities that will result from it.

Energy Markets in the United States. While turning on a light switch to power a lamp may be a very simple task, the pathway that the electricity took to get from the raw fuel to your living room is much more complicated. This includes the electricity's journey through the various energy markets in the United States, or the regional systems responsible for the operations and management of electricity in their part of the country. In the United States, there are currently 2 different types of power markets: regulated and deregulated. An understanding of these markets and the differences in the ways they provide electricity to their customers is crucial to forecasting what changes can be made to this system to make it more sustainable and reliable for the whole country.

Regulated energy markets operate as vertically integrated monopolies. In these markets, there is one company that controls all of the processes involved from generating electricity to its distribution to customers. This singular utility also controls the ratio of sources that the energy comes from, meaning that they can choose how much electricity comes from nonrenewable and renewable sources. The southeast United States and the entire western United States (apart from most of California) operate in separate regulated energy markets named the Southeast, Northwest, and Southwest.

While monopolies are generally considered to be harmful to consumers, state regulators oversee these regulated markets to ensure that consumers are given a fair price for the electricity they have to buy. This prevents utilities for overcharging for electricity by setting a "revenue requirement" that allows for these companies to earn an agreed upon rate of return for their services (Cohen 1998, 4-6). Supporters of regulated energy markets point to the high cost of entry to produce energy as a reason for keeping the monopolies in place, stating that energy production should be left to established participants who can provide reliability to customers. A possible downside to regulated energy markets is the lack of motivation for innovation; utilities with a guaranteed customer base have little reason to invest in more cost-efficient technologies or different energy sources because their market share will not change anyway. This was the norm for decades, until individual states pursued a different market structure to attempt to facilitate competition and lower consumer prices – deregulation.

In deregulated energy markets (also sometimes referred to as "liberalized" energy markets), independent firms not associated with the utility own the means of electricity operations, such as the power plants and the transmission lines. In these markets, the companies that generate electricity sell it to retail energy suppliers who then sell and distribute it to customers. The selling of energy requires the presence of an independent system operator (ISO) or regional transmission organization (RTO) to oversee this market. Deregulated energy markets were introduced to create competitive markets for suppliers to innovate and offer more lucrative energy offers, such as the use of demand response or renewable energy sources. Two-thirds of the United States operates under deregulated energy markets, including Texas, the Northeast, and the Midwest.

The deregulation of energy markets in the United States began in the 1990s, so examining changes in energy prices, innovation, and efficiency between the two types of markets can show which one is better served to usher in the coming energy transition. Historical data on energy price difference between the two markets is inconclusive. A recurring theme among most studies is that when an energy market is first deregulated, there is a decrease in energy bill prices, but long-term studies show that these differences often balance out (MacKay and Mercadal 2021, 3-4, and Necoechea-Porras et al 2021, 20). Deregulated markets were partially introduced to lower energy prices, so the absence of a regularly noticeable difference has surprised some economists. One explanation for this could be a high rate of markups in deregulated energy markets as producers seek to increase their profits by overcharging for energy, a problem which is avoided in regulated markets by state regulators setting energy prices at a “fair” rate (MacKay and Mercadal 2021, 5). In the case of overcharging in deregulated energy markets, the market would cease to be perfectly competitive and the benefits of more efficiency and lower operating costs would be offset – this problem could only be solved by legislation and price controls, but it has not yet been statistically proven.

A possible source of this overcharging in deregulated states are added post-generation regulatory charges. For example, a 2023 study on energy prices in the midwestern United States showed that deregulated states like Ohio saw, overall, lower energy prices than nearby regulated states such as Michigan (Bowen et al., 2023, 50-52). The results showed that the main reason for this cost difference was a decrease in the overall cost of power generation in Ohio, which is an expected result of the competitive pricing that comes with a deregulated market. However, this cost decrease was offset by a regulatory-approved increase of transmission and distribution prices, which has been repeatedly observed in deregulated markets across the country (Dormady et al., 2019 and Simeone and Hanger, 2016). In Ohio specifically, total energy bill costs represented transmission and distribution rose by 8% while the power generation costs fell by the corresponding 8% (Bowen et al., 2023, 49-50). This means that the cost reductions caused by deregulating energy production are sometimes completely offset by an increase in the price of other means of power distribution – this could be a possible cause of the similarities between energy prices within the two different market types.

Deregulated markets are also meant to have an impact on innovation, which is a necessary component of the energy transition, especially related to renewable energy expansion and energy storage technologies. The ability for competition between producers in deregulated markets is meant to cause market players to invest more into innovation to offer lower prices and more efficient solutions. For example, when the prices of nonrenewable energy sources rise, operators in deregulated markets have an incentive to invest in alternative energy forms to be able to offer energy at a lower price. However, studies show that this is not always the case. The existing United States focused literature on this topic shows mixed results in both the money spent on research and development as well as patent filings between the two types of markets.

A possible reason for this lack of clarity is because energy innovation in the United States often takes place on a national level rather than by individual states. Therefore, it is useful to look at examples of country-wide energy market deregulation and how this impacted innovations in renewable energy. In the United Kingdom, for example, renewable energy patents significantly increased in the years following their transition to complete deregulation (Nesta et al., 2014, 398). However, it is logical to assume that renewable energy innovation would increase over time regardless of market structure because of innovation in adjected sectors and by private players that do not have a hand in energy generation or distribution.

Externalities and Valuation. Every economic decision a person or entity makes has a financial cost to it, such as spending $10,000 on solar panels or multiple billion dollars on a brand-new power plant. These decisions also have external costs, which can be thought of as side effects of these decisions that impact parties that are not directly involved with the decision. Most importantly, externalities are not reflected in the monetary cost of the decision. Externalities can be positive, as in the case of a person spending money on a holiday lights display that increases the happiness of their neighbors. The added value of this happiness is not factored into the price of the lights at the store, so it is a positive externality. Unfortunately, most externalities, especially environmental externalities, are negative. When a celebrity chooses to fly a private jet over a short distance, the amount of local air pollution increases. The impact that this has on the local residents and the environment is not factored into the price of this decision, so it is known as a negative externality.

Environmental externalities are the uncompensated impacts that certain decisions have on the environment, and most are negative. The nonrenewable energy sector causes many negative environmental externalities. For example, the processes that are used to extract coal, oil, and natural gas all have large environmental footprints that led to water pollution and habitat loss. The combustion of these fuels then leads to air pollution, which has been shown to have detrimental impacts on human health as well as the health of the planet overall. Renewable energy also has externalities, many of which are positive, such as a reduction in carbon emissions, increases in local air quality, and job creation. There are still some negative externalities though, such as the audiovisual aspects of wind farms and the impacts they can have on wildlife.

The many negative externalities of nonrenewable power generation all have an impact on the Earth's natural capital. Natural capital is the same as any other form of capital that powers an economic system, such as financial capital. What sets natural capital apart is that it is not produced by humans, but instead is "provided by nature for free" (Helm 2016, 2). It can take many forms, including all of the natural resources that society uses every day such as freshwater and soil. Natural capital also encompasses all of the essential ecosystem services previously discussed in Chapter 1, such as climate regulation and photosynthesis.

The main problem with externalities and natural capital are that most of their value is nonmonetary, as compared to other types of goods and services which have a clearly defined price. For example, it is very difficult to put a price on the value of clean air for a neighborhood, but one could easily find out the current price for 1 ton of coal. For decades, economists and environmentalists have both tried to find ways to monetize these resources and the values they hold. If we were able to know what a particular ecosystem service or piece of natural capital is worth, we would be able to offset any damages to it by factoring its degradation into the price of environmentally harmful actions. Although there is not a universally accepted way to monetarily account for environmental impacts, there are various theories that can help to better understand how environmental externality valuations are commonly received by the global community. Perhaps the best example of this are carbon credits.

Carbon credits work as a pollution allowance, where a company purchases the right to emit a certain amount of CO_2 (in tons) from its government. The government sets a total limit of these credits that are available, presumably a number that meets a predetermined emissions target. Companies that exceed their allotted carbon credit amount are punished or fined until they reduce their emissions to the agreed upon level. In some cases, companies that emit less than they are allowed to can sell their unused credits to other companies that have exceeded their limits, known as a "cap-and-trade" program. Thus, this system puts a monetary price on a ton of CO_2 emission.

In a perfect world, this strategy would work well to reduce carbon emissions as well as create an incentive to innovate to less carbon-intensive practices. Unfortunately, there are not many carbon credit markets in existence today. This can be blamed on many of the difficulties in environmental externality valuation that were explained above. One of the main drawbacks is that CO_2 emissions are difficult to accurately measure and can be easily hidden, which creates a problem when trying to evaluate the true price of a ton of carbon. The price itself is also hotly contested and often varies wildly. For example, the Obama administration valued carbon at about $43 a ton while the Trump administration estimated the price would be less than $5 per ton (Asdourain and Wessel, 2023).

Many environmental advocacy groups have also spoken out against the adoption of carbon credits, carbon offsets, and the cap-and-trade program as they believe that it would lead to greenwashing. Their prediction is that giving companies the ability to purchase a route to lowered emissions without having to make any tangible progress towards their targets would only be generating revenue for the government and further normalizing fossil fuel usage. While it is difficult to test this hypothesis as there have not been many functional carbon credit markets worldwide, recent studies and the history of greenwashing in general can show that this theory may not be incorrect (Trouwloon, et al., 2023 and Abadie et al., 2023).

These difficulties in environmental externality valuation show why it has been such a hotly contested topic for decades. There seems to be no way to agree on how these externalities should be factually accounted for or priced. Perhaps the best way to value externalities is through the realization that the benefits that human society reaps from the natural environment are dwindling. Loss of biodiversity, deterioration of the tourism industry, and rapidly rising temperatures (just to name a few) are all causing global monetary losses. While it may be too late to regain all of these losses, there are many economic benefits to sustainability, especially in grid modernization, that can help take their place.

Economic Drivers of Grid Modernization. As explained in section 2 of this chapter, externalities are difficult to measure and almost impossible to assign a monetary value. It may be obvious that there are more social and environmental benefits to using renewable energy versus nonrenewable energy, but these benefits are difficult to quantify, especially monetarily. However, there are ways to look at the economic benefits of an energy transition that can help explain why it would be a beneficial economic decision for the United States.

One major economic benefit of grid modernization is the increased resilience and energy security that will help protect against natural disasters and other threats to the energy grid. Any impacts to our ability to produce or supply energy can have drastic economic and personal impacts, as exemplified by the 2021 Texas winter storm. This unexpected weather event caused over 4 million houses to lose power as well as the access to heat and water for a multi-day span in February 2021. It is estimated that the loss of power and inability to quickly solve the problem led to between $195 and $295 billion in harm (*Lessons Learned,* 2021).

These costs could have been drastically reduced if Texas's grid was completely modernized. For example, Texas was not prepared to call on auxiliary power plants for quickly available loads to meet the increased demand (Busby et al. 2021, 4). Texas's grid interconnection is also cut off from other states' grids, meaning it is difficult to draw power from other areas. This problem is unique to Texas, which does make this case an outlier in terms of its generalizability. However, their lack of grid resilience and the costs that resulted from it shows the dangers of having a grid that is unable to handle extreme weather events, among other threats. For Texas's example, the cost of implementing the strategies to modernize their grid would have been drastically less than the estimated costs that they suffered. The Texas winter storm is a very dramatic example of the dangers of natural disasters, both in scale and in likelihood. However, it does provide a good example of how many costs are associated with the inability to provide power and how quickly these costs can increase when the problem cannot be solved quickly.

As previously mentioned, modernization of the United States energy grid is a massive undertaking that will require years of consistent work and political support to achieve. One of the most fundamental pieces to this transition is an expansion of the clean energy workforce. New workers will be needed in jobs up and down the value chain, including operators, installers, and engineers to work directly with energy technologies like windmills, solar panels, and newly constructed power lines. While job creation and job growth can be difficult to accurately forecast, any expansion of the energy sector will undoubtedly result in an increased demand for laborers to help usher in an energy transition. Lowering unemployment and increasing the number of high skill jobs brings substantial economic benefit will bring a substantial economic benefit to the United States.

While this energy transition will take years to complete, recent steady growth in United States clean energy jobs shows that progress is being made at expanding this employment sector. In 2022, the United States energy workforce grew by 3.8%, with half of those jobs being related to clean energy expansion according to the 2022 Department of Energy Executive Report. In the electric power generation sector, over 84% of the jobs added were in clean energy technology showing how growth in renewable energy is continuing to eat away at the market share currently owned by fossil fuels. These recent single year trends in the United States support both historical clean energy job expansion as well as projections for future growth. For example, data from the International Renewable Energy Agency (IRENA) shows that worldwide renewable energy jobs grew from 7.28 million in 2012 to 12.67 million in 2021, representing a 74% increase over the ten-year period (IRENA and ILO, 2022).

These figures are expected to continue to rise in the coming decades as many countries push to increase their consumption of renewable energy and begin full scale energy transitions. A recent study by Ram et al. in 2021 projected that worldwide direct energy jobs will need to increase by 135% to 134 million in 2050 to reach the lofty goal of 100% clean energy use by that point (Ram et al., 2021). This includes rapid expansion in clean power generation, battery storage technologies, and plant-to-grid transmission technologies coupled with a decrease in the overall jobs in the fossil fuel industry (Ram et al., 2021). As previously mentioned, the arbitrary decision to finish a clean energy transition by 2050 is relatively unlikely, but the scale of these figures underlies the huge economic benefits that can be realized by a successful energy transition. However, any sustained movement towards said transition would lead to a huge increase in clean energy job demand, providing large economic and employment benefits to a country that undertakes this challenge.

Chapter 4 – The Politics of Energy

Politics play an extremely important role in any form of societal change. They can either spearhead a transition from start to finish or act as a roadblock to any meaningful developments. This is especially true in relation to the environment and the fight against climate change. Progressive and proactive political agendas can pave the way for comprehensive strategies, encouraging investments in renewable energy, and setting emission reduction targets. Conversely, political polarization or reluctance can impede progress, leading to stagnation in enacting necessary reforms and hindering the transition to a more sustainable and low-carbon future. Analyzing the intersection of environmental politics and energy transitions can provide insight into strategies that will continue to work efficiently as well as reasons why past events have not been as effective as one would have hoped (Rosenbaum 2019).

Relationship Between Politics and Energy Transitions. As previously discussed, the first global energy transition occurred during the industrial revolution when wood was replaced by coal as the world’s primary energy fuel. Since this initial transition, countries across the world have pivoted away from the use of coal in favor of cleaner burning fuels, such as natural gas and nuclear power. Analyzing the political momentum behind these transitions that have already happened can show what is required for our country to begin its next transition to renewable energy and an entire overhaul of our electric grid.

In the United States, coal reigned supreme from the late 19th century into the first half of the 20th century, when it was eventually overtaken by natural gas. This transition was fueled by political movements that aimed to reduce emissions and pivot the United States to cleaner energy sources. The major policy that spearheaded this change was the Clean Air Act of 1963, which was the country's first policy that worked to control and restrict air pollution. This act was hugely impactful to energy use in the United States, as much of its restrictions were aimed at cracking down on outdated power plants.

A recent study from the National Bureau of Economic Research studied the impacts on the United States' operational power plants in the years following this policy's passing in 1963. It discovered that plants which were built before 1963 saw significant decreases in both output and efficiency as they struggled to comply with the new regulations, and many were shut down as a result (Clay et al. 2021, 30-60). This is one of the major victories for the Clean Air Act, as the United States' heavily polluting coal power plants were almost completely phased out in favor of natural gas power plants or more efficient coal plants (Clay et al. 2021, 50).

However, the study also found that power plants built after 1963 that complied with the Clean Air Act's pollution standards saw very little change over time and were able to easily adapt to future amendments to the Act (Clay et al. 2021, 70-89). These post-Act fossil fuel power plants have been able to remain in operation because of the Clean Air Act's relative stagnation on its emission standards. Its initial victories in closing down inefficient power plants shows the power of legislation within the energy sector, but the lack of continuous regulation shows how problems can easily go unsolved without standards being tightened. While the United States has not been very successful in showing consistent support to clean energy policy, other major countries around the world can provide more insight into the benefits of determined political backing for energy transitions.

One such example is France's nuclear transition. During the aforementioned OPEC oil embargoes of the 1970s, France recognized that their dependence on foreign powers for oil imports could lead to future energy crises in the wake of international unrest. To avoid this, they chose to begin a nearly complete transition to nuclear power. This idea was not popular at first; citizens and scientists were skeptical of nuclear power's safety and reliability, and lobbyists wanted to maintain government support for their traditional oil and gas pipelines. Despite this, France's government remained committed to their plan. Over the next 30 years, France built 58 nuclear reactors and increased their nuclear output from 5 Mtoe (mega tons of oil equivalent) to over 100 Mtoe (Solomon and Krishna 2011, 7425). Today, 68% of their energy comes from nuclear power and they are a global leader in nuclear power research and expansion (IEA 2010, 479).

Compared to other energy transitions, France's switch from fossil fuels to nuclear power was quite fast and efficient. So, what did they do differently? The most important aspect of their energy transition was unwavering government support. Even though administrations changed, and public opinion wavered, the government as a whole never stopped funding their nuclear expansion projects because they were committed to achieving their goal. They knew an energy transition was necessary to decrease their reliance on oil imports and help reduce their impact on climate change, and they ran publicity campaigns to inform their citizens on the benefits of this transition.

To enact a modern energy transition in the United States, we need to understand the reasons behind past successes as well as recognize why some have fell short. The United States' Clean Air Act of 1963 shows that energy policy can enact quick and sweeping change across the energy sector. However, a lack of consistent government support and policy updates can lead to these changes being limited in scope. France's example shows what can happen when a government does provide this constant political backing and funding, as they were able to usher in a significant energy transition from fossil fuels to nuclear power. These steps can be followed today to see renewable energy take the place of fossil fuels, but this transition will need to be sustained by our government for decades and not by just a few policies and regulations.

Renewable Energy Policy. Any sweeping societal change must be backed by political policy that mandates its adoption, or at least significantly encourages it. Because of this, the fight for the widespread adoption of renewable energy is inherently political. Unfortunately, energy policy in the United States moves slowly and is often impacted by the lobbyists and biases that work to keep the country totally dependent on fossil fuels. Changing energy cannot be done without political momentum, and this section will explain current policies in place to help the adoption of renewable energy as well as examine their shortcomings and look into reasons why they may not have been as successful as intended.

To begin, it is important to understand where renewable energy policy stands in the American political landscape. Renewable energy expansion is intrinsically linked to climate change mitigation, as it represents one of the best strategies available for reducing air pollution. The partisan divide on climate change has, therefore, somewhat spread to renewable energy. However, it has been shown that Americans are, on average, more supportive for renewable energy expansion than they are for policies that specifically mention climate change mitigation (Hamilton et al., 2018). While the two topics are definitively linked together, the more common support for renewable energy may be linked to its economic benefits. For example, Republican leaders have been historically more in favor of household solar panel installation tax rebates than they are for industry-wide subsidies (Hazboun et al., 2020). This way of thinking has shaped much of the United States' renewable energy policy to this date.

As of 2023, the "Residential Clean Energy Credit" program is the United States' leading policy that encourages the adoption and use of renewable energy sources. Under this program, homeowners who install clean energy improvements to their homes can receive a tax credit for up to 30% of the cost of the installation. This current iteration of the clean energy credit is scheduled to be in place from 2022 to 2032 and covers the installation of various types of renewable energy technology, such as solar panels, geothermal heat pumps and fuel cells. Tax credits have been a staple of United States policy that aims to increase renewable energy usage. The first renewable energy tax credit was introduced in the Energy Policy Act of 2005, which provided homeowners with a credit for only 10% of renewable energy installations and was capped at a maximum of $1,500. This original iteration of the renewable energy tax credit also did not cover the installation of solar panels, so it is clear that there has been progress made in the years since the United States' first tax credit (Brulle 2018, 290).

Renewable energy tax credits have been largely successful in expanding the usage of clean energy technology in the United States, particularly in solar energy. According to the US Energy Information Administration, in 2010 the United States imported and domestically produced 2.5 million peak kilowatts of solar panels. In 2021, this number rose by over 1000% to nearly 28 million peak kilowatt hours. This was caused, in part, by huge reductions in the cost of installing solar panels, which fell from $7.53 per watt in 2010 to just $2.71 per watt in 2020 according to the National Renewable Energy Laboratory. This progress can be attributed to the renewable energy tax credits that helped make installing solar panels a more economically viable option for households. This increase in demand led to growth in solar panel efficiency as well as a decrease in overall cost, rapidly expanding the solar sector to its current size in only two decades.

The statistics mentioned above show that tax credits are successful at expanding renewable energy markets and encouraging their adoption, but the scope of tax credits will always be limited to the individual. A tax write-off for 30% of installation cost is a good start, but renewable energy technologies are still expensive – solar panel installation on the average home still costs about $15,000, before applying any available tax credit. Renewable energy use is still limited to homeowners with disposable income and a high willingness to pay for using clean energy, which is not a large subset of the United States population. While it is encouraging to see renewable energy tax credits renewed as they continue to expand the renewable energy sector, they do not represent the sweeping societal change that is needed to bring about a true energy transition.

Overall, the main reason for the success and consistent presence of renewable energy tax credits in the United States is that it frames the energy transition as economically beneficial, rather than environmentally crucial. This theory is supported by a 2017 survey conducted by Stokes and Warshaw in which participants' attitudes towards renewable energy standards were measured based on how the prospective bill was framed. They found that policies with an emphasis on job creation had widespread support, especially in Republican dominated states. However, when the policy was tied to even a marginal increase in energy bill prices, its support fell dramatically (Stokes and Warshaw 2017). The researchers concluded that public opinion on renewable energy policies is directly tied to its economic benefits, and this finding has a large implication for future energy policy in the United States. If renewable energy is correctly or incorrectly blamed for an increase in energy bills, the policy will see much less widespread support.

Another key piece of the United States' renewable energy policy puzzle is there is often a lack of long-term vision attached to future renewable energy plans. As previously explained with France's nuclear energy transition, their relative success was a product of consistent government support over a period of over 50 years, something that the United States has never had. For example, Donald Trump's presidency was a period of complete stagnation for renewable energy policy. Trump's energy policy was defined by his "America First Energy Plan" that emphasized domestic fossil fuel production and had no plan for renewable energy expansion (Vakhshouri 2017). Conversely, Joe Biden's successive presidency has championed renewable energy development and expansion, calling for an increase in budget size and setting decade-long goals for operating capacity and industry expansion. At the time of writing, it seems that the 2024 presidential election will again be contested between Joe Biden and Donald Trump. If the latter is elected, it is almost guaranteed that much of the Biden administration's progress and promises will be wiped away.

This phenomenon is not a result of two wildly different administrations, but rather a continuation of a trend that the United States' two political parties are unable to agree on the means to achieve long term goals. Even if the end result is mutually agreed upon, shifting control and policies often slow down tangible progress. For example, the two political parties generally agree on the need for an alternative to gasoline powered vehicles. In 2003, republican President

George W. Bush announced his support for research into a hydrogen powered car. However, when democratic President Barack Obama took office in 2008, he favored the expansion of electric vehicles instead and cut the funding for hydrogen powered cars by 80% (Elliott 2013, 43). While renewable energy policy is much different than alternatively powered vehicle policy, the constant shifting in United States' governmental thinking still applies. Until there can be a solution that sticks beyond administration changes, any policy will be slow moving and consistently altered.

Another common phenomenon that slows down renewable energy policy progress is lobbying. Lobbying does go both ways on this issue, as environmental coalitions and renewable energy companies also campaign for policies to target climate change and devest from fossil fuels. However, the gap between their influences represents another one of the reasons why United States energy policy is historically stagnant. From 2000 to 2016, fossil fuel companies reported $370 million spent on lobbying efforts, while renewable energy companies and environmental organizations combined to spend only $126 million (Brulle 2018, 296). These figures also don't include the massive influence that fossil fuel companies have in states like Texas, Pennsylvania, and Louisiana where fossil fuel extraction and production make up large parts of the economy and job markets.

Overall, renewable energy policy in the United States is often championed for its economic benefits rather than its environmental necessity. While any form of progress is wholeheartedly welcomed, there will need to be a shift in thinking if any long-term goals are to be met. Differences in opinion between administrations and the constant presence of lobbyists also work against long-term progress. Despite all this, the renewable energy sector has seen consistent growth in the 21st century by all available metrics. Whether this is thanks to our government or despite it is hard to say. What can be said, however, is that there is room for greater efficiency in our policy decisions to see that the renewable energy industry continues to grow to meet the targets set by our elected officials as well as meet the needs of our planet as a whole.

Energy and International Relations. As previously discussed in Chapter 2, international relations and worries about foreign dependence led to the beginning of energy transition policy in the United States. In the 1970s, political unrest and oil embargoes in the Middle East caused the United States government to become conscious of their reliance on oil as well as the countries who supplied it to them. While the world of today is much different from the 1970s, there are still almost constant threats of wars and conflicts that all involve the United States in some way. It is important to understand how our energy grid is tied to foreign powers and the producers of commodities we need to import to fuel our own energy transition. Analyzing this can provide insight into the feasibility of an energy transition and how much of its success is tied to the United States' international political standing.

In many ways, the same fears about energy security and foreign dependence that surfaced in the 1970s still drive energy policy decisions of today. Richard Nixon's administration first introduced the idea of American energy independence, an idea which has been continued by presidential administrations of the 21st century. Although renewable energy has gathered support as a possible future of domestic energy capabilities, much recent policy has focused on expanding the domestic production of fossil fuels. According to data from the US Energy Information Administration, United States energy consumption has remained constant since 2000, so this expansion has not been done to meet increasing demand. Instead, it is because our country remains focused on meeting the goal of energy independence, which we aim to do through fossil fuels.

For example, President George W. Bush's "national energy plan" focused on expanding domestic capabilities for fossil fuel production, exploration, and extraction (Nyman 2018, 130-138). He did support the expansion of renewable energy technologies but prioritized bolstering the domestic fossil fuel industry. Bush was succeeded by Obama, but although the political party of the executive branch changed, its stance on domestic energy remained largely the same. President Obama championed an "all of the above" approach to achieve energy independence, which did include renewable energy expansion but also led to increased drilling and fossil fuel extraction – as a result, domestic oil and gas drilling reached a 21st century high under President Obama in 2011 (Nyman 2018, 133).

This shows that regardless of political affiliation, the United States remains committed to achieving energy independence through fossil fuel expansion. One of the biggest goals of this move for energy security is to completely cut off reliance on unstable foreign powers for fuel. Overall, it has been successful – the vast majority of United States energy imports now come from Canada and almost none from OPEC countries, Russia, or Iran according to data from the US Department of Energy. However, there is a recurring pattern which shows that fears of unstable international relations consistently push the United States further towards fossil fuels and leave renewable energy production as an afterthought. If an energy transition is to happen in the United States, our government will have to recognize that it can protect itself from global unrest through the use of renewable energy and energy efficiency technology and not just consistent expansion of the fossil fuel industry.

While a complete energy transition is extremely far away and unlikely at best, it is important to consider what impacts it would have on international relations. As with any decision, there will be winners and losers; it is important to analyze which geopolitical benefits downsides would exist from an energy transition. Renewable energy resources are much less geographically specific than fossil fuels, meaning that every country in the world has at least some capacity to generate clean energy, depending on their geography. Some scholars, such as Casertano and Sweijs et al., argue that decentralization of energy production will lead to a time of international peace by eliminating any conflicts that could possibly arise over fossil fuel exports, transportation, or extraction. This would be especially beneficial to nations who completely rely on fossil fuel imports to power their economy, as much of the world currently does. Renewable energy expansion would therefore create a pathway to self-sufficiency. (Casertano 2012 and Sweijs et al. 2014).

One possible downside to an energy transition is the collapse of "petrostates" that completely rely on fossil fuel exports for their income. If petrostates' most popular customers were to suddenly not need them anymore, conflict could arise as they struggle to maintain influence without their chief export. In recent years, we have seen petrostates begin to diversify their domestic portfolios away from fossil fuel exports as a path to remain economically viable if the world shifts away from oil. A major example is tourism and infrastructure: Qatar hosting the 2022 World Cup and the United Arab Emirates' investment into Dubai as a global tourism destination are common examples. While these projects have been somewhat successful, David Rothkopf argues that an energy transition will still have major geopolitical consequences resulting from the collapse of these countries, possibly including the final installment of oil wars and other border conflicts (Rothkopf 2009).

Historically, much of the United States' international energy policy has focused on the prospect of domestic energy security. While the USA does possess a considerable wealth of fossil fuel reserves, the true path to long term energy security lies in renewable energy, which we know will not run out any time soon. With the highly complex geopolitical nature of energy, any large energy transition will inevitably have a wide range of impacts on our international relations. As the United States begins an energy transition towards renewable energy, our government will have to be aware of the international consequences it will have, specifically its impact on middle eastern petrostates.

Chapter 5 – Policy Recommendations

While the previous four chapters have explained the current state of energy and electricity in the United States and why we need an energy transition, no progress will be made without political momentum and consistent policy. Chapter 4 explained the relationship between policy and energy, showing that policy has been successful in changing societal norms around energy, but these policies will need to be built upon and strengthened if an energy transition is to happen in the United States. Political will and leadership are crucial in driving policies that address environmental challenges and combat climate change. Proactive political agendas can pave the way for strategies that will update our energy infrastructure, encourage investments in renewable energy, set emission reduction targets, and foster cooperation, all steps that are necessary for an energy transition.

Market Reorganization. One of the most fundamental ways for the United States to usher in a timely energy transition is by rethinking the ways that our energy markets are organized. As explained in Chapter 3, energy markets are currently characterized by confusing borders and inconsistent overlaps in jurisdiction that can hinder progress. The energy transition that the United States needs will require the ability to quickly turn ideas into legislation into results in an efficient manner across the country, and the current regulatory set-up is unable to make this happen. The United States also needs to develop the ability to transport energy quickly and efficiently across the country, which is difficult with a disconnected energy market system. This is why government reorganization is necessary for an energy transition.

The main theme of this change is a need for nationwide homogeneity of energy governance, which is not currently the case. As mentioned in Chapter 3, the United States is currently made up of two different types of energy markets: regulated and deregulated. While statistics and existing literature are inconclusive as to which type of market yields lower prices or higher efficiency standards, the fact that two different types of markets both exist in the United States is definitely bad for interstate energy cooperation. For example, a city that sits on the border between two different energy markets has difficulty sharing energy among all residents, and some residents may be eligible for programs that others are not. America's energy grid of the future will require different states and markets to be willing and able to share their capacity to generate electricity, and the easiest way for this to happen is through nationwide mandates on energy market type.

The most effective and efficient way to do this is by instituting Standard Market Design. This is a nationwide standard that would put all of America's energy producers and consumers on a level playing field. One of the main hallmarks of this plan is a standard transmission tariff that applies to all energy utilities, proportional to the amount of energy that they distribute. Current transmission tariffs are complicated and vary between states and utilities, which makes it difficult to homogenize access to new load management technologies and renewable energy technologies. This plan would, in theory, allow all Americans to access new technologies that could reduce their energy usage or change energy sources.

Another benefit of a standard transmission tariff is that it eliminates the disconnectedness of energy transmission in deregulated markets. As discussed in Chapter 3, different market participants can own power plants, transmission lines, and the transmission grid. While this can introduce competition between energy producers, it also means that there are multiple different firms introducing their own costs into the energy transmission process. This is one of the reasons why deregulation of energy markets has not had the hypothesized long-term reduction in energy prices for its customers. In Standard Market Design, transmission assets are operated by an independent grid operator that is solely focused on efficiency and reliability, not on profit. The standard transmission tariff is designed to accurately compensate the grid operator for operation costs, without the ability of the operator to change the tariff themselves. This ensures that all costs remain transparent and accurate to the services provided.

Standard Market Design adoption would also be crucial for increasing competition and new technology adoption rates across the country. Currently, if an emerging firm wants to offer an electric load managing product, they would only be licensed to operate in certain states or markets where their product is legal. This could impact the success of this technology's future and also deprives a large portion of the country of the opportunity to take advantage of it. The current pathway for a new technology to be adopted across energy markets is by issuing an official notice to FERC, which then must review it internally, before it notifies stakeholders. This process is complicated and time-consuming, which has hindered the ability of technologies like demand response to take root nationwide. Standard Market Design eliminates the need for this approval process, as FERC will no longer have to decide if new innovations would be legal in different states or markets.

As a result of this, it is logical to assume that nationwide energy prices would decrease as a result of Standard Market Design. Less required regulation for the adoption of new technologies and fewer barriers to entry into the market would mean that energy and cost saving measures could develop nationwide at a faster rate. This is especially true for demand response and flexible load management technologies, which are currently limited to certain parts of the country where they are legal. Renewable energy would also see expansion under Standard Market Design because of these new incentives for innovation and competition. Transparent pricing and sourcing under SMD would create an incentive for producers to offer more renewable energy options, thus creating a motivation for the expansion of renewable energy technologies and services.

Overall, Standard Market Design represents a much-needed modernization of American energy markets. The current market organization is inconsistent and does not represent the necessary coast-to-coast interconnectedness needed for an energy transition. Levelling the playing field for all market participants will increase competition and the adoption of energy saving and renewable energy technologies. It will also encourage cooperation between states and regions that were previously unable to share energy loads. Adopting Standard Market Design is a crucial first step in ushering in an energy transition.

Infrastructure Advancement via Government Restructuring. One of the major consequences of the detachment of regional energy markets is the lack of infrastructure connectivity. As mentioned in Chapter 2, the United States energy grid was initially constructed as a patchwork combination of local energy transmission networks – it was never designed for coast-to-coast reliability or interconnectivity. As such, it is difficult to transmit power between regions because the long-distance infrastructure is either nonexistent or unable to do so. The consequences of this were realized during the 2021 Texas winter ice storm in which Texas' grid was unable to receive power from other parts of the country to cover the energy demand it was unable to fulfill when its power plants went offline.

As discussed in Chapter 2, the first large scale energy transition in the early 1900s began with the creation and expansion of the first energy grid to transport electricity from generation sources to households and businesses. It is now time for another energy grid construction project, as our country is now in need of a system of long-distance power lines to transport clean energy from areas of high supply to those with high demand. As explained in Chapter 1, renewable energy is often found in areas with low demand but high supply, such as solar energy in the southwest or wind power in the Midwest – long distance transmission lines are needed to bring this abundant energy to cities across the country. This is not a simple project, and it will require years of consistent bipartisan cooperation and funding to accomplish. But its many benefits, including job creation, domestic energy security and renewable energy expansion, make it a rewarding and crucial effort to undertake.

One of the biggest reasons why infrastructure advancements take so long to enact is the complicated approval process they require. Transmission lines are no different, as they need to be signed off on by numerous committees, utilities and local governments before construction can begin. I believe that there should be a federal agency with the authority to bypass these signatures to get multistate transmission lines approved faster. Currently, FERC has jurisdiction over these infrastructure projects, but they have been ineffective in seeing them from start to finish in a timely manner due to rigid and complicated approval processes, as well as inconsistent political support.

A way to bypass this is through expanding FERC's federal power to be able to push past local regulations for crucial energy infrastructure projects. This would include the ability to build transmission lines on federally owned land and upgrade existing infrastructure to new standards for long distance power transportation. This goes hand in hand with Standard Market Design as ways to level the playing field for all energy market participants, as more customers will have access to new technologies and renewable energy because the infrastructure can support its transmission over long distances.

At the heart of this energy transition is expansion to renewable energy, and infrastructure advancement is crucial to this goal. As discussed in Chapter 2, previous energy transitions and energy policies have resulted from changes in price and access. For example, the United States' widespread adoption of coal in the 19th century resulted from the construction of new railway lines that made it available to new populations and thus expanded the market. This is an opportunity to do the same for renewable energy. By constructing long distance transmission lines capable of transporting renewable energy to new markets, more people will gain access to renewable energy. This will, in turn, increase renewable energy's market size and encourage market players to expand their clean energy capacity.

Supporting all Solutions. As mentioned previously in this paper, there is not one single strategy or technology that will help move the United States away from its dependence on fossil fuels and towards reliable renewable energy. Instead, each concept should be allowed to expand and capture as much of the available market as it can – some would refer to this as an "all of the above" approach. All solutions will be needed in order to restore the health of the many ecosystem services that are impacted by the pollution of the energy sector as was discussed in Chapter 1. Future policy should reflect this mindset by encouraging research and development and supporting new strategies that can help increase energy efficiency, facilitate competition, and strengthen clean energy usage.

One possible policy would encourage the adoption and expansion of demand response technology for states and utilities as well as individual market participants. Demand response technologies have been steadily expanding as a way to utilize distributed energy resources (DERs), such as batteries and solar panels, to reduce energy use in times of peak demand and supplement energy capacity when needed. I believe that this is a very cost effective and efficient strategy to cut down on the amount of energy that a utility needs to produce at any given time, but its impact can be limited because of the voluntary nature of participants. FERC Order 2222 issued in 2020 has been a good step in the right direction by allowing for DERs to be become real participants in deregulated energy markets, but the limited scale of FERC's jurisdiction means that there is still a lot of capacity not able to be used by demand response technologies. I believe that policy should encourage, or even mandate, the use of DERs in demand response programs across the country.

I have also found that public participation in an energy transition is extremely important, both through support for policy through voting as well as for individual cooperation with sustainable energy programs. Recalling the interview I conducted for my introduction of this paper, my largest takeaway was that my former boss believed that the average person does not understand the importance of an energy transition or the challenges facing the United States' energy grid. If the public was properly educated on these problems and the solutions that we can adopt to solve them, I believe we would see the government act more efficiently to push policy forward.

Specifically, the government should begin an information campaign which explains the benefits of clean energy and energy efficiency, such as job creation and lowered energy bill prices. As discussed in Chapter 3, lowering energy bill prices can be seen as a large reason for supporting an energy transition, so this point should be emphasized to the public. Also, local governments and organizations should be included in the planning process for large energy infrastructure projects so their concerns can be heard, and the benefits fully explained. In cases where a transmission line project would negatively impact a certain community through construction backups or property devaluation, utilities could be forced to engage in a profit-sharing program with the local utilities to reduce the costs of energy for those effected. All of these strategies would help increase public opinion of an energy transition, with priority given to those that emphasize the cost-saving nature of energy saving strategies and projects as these will most likely be the most persuasive on an individual-by-individual basis.

Renewable Energy Expansion. As mentioned previously in this paper, renewable energy has been steadily expanding in the United States during the 21st century, but this progress will have to increase at a faster rate to usher in a true energy transition. Federal and state policies have proven to be effective in encouraging the use of renewable energy sources and expanding their markets, showing that policy is a successful way to see growth within this sector. However, as mentioned in Chapter 4, these policies often run into obstacles that can derail progress before it is realized. For any of the following policies to be enacted, there has to be a larger shift of consciousness in which our government understands the necessity of a clean energy transition and can ignore the persuasiveness of the established fossil fuel industry.

The United States itself, and most of the states within it, currently has a renewable energy portfolio standard and a date set as their goal for achieving 100% clean energy usage. For example, the Biden administration recently set a goal to achieve 100% pollution-free electricity by 2030. While this is a comforting thought, it is unrealistic and ambiguous. Clean energy goals should be based on achievable targets that motivate both short- and long-term policies, such as incremental increases to renewable energy goals. An example of this would be a policy to increase renewable energy's share of energy generation by 1-2% every year until 2035: this goal is much more realistic and also provides a step ladder for an energy transition to happen instead of a lofty expectation set way out in the future. This way of thinking should apply not only to the federal government's targets, but also to state specific targets. Changing this mindset would help the government see an energy transition as an achievable set of goals rather than an arbitrary futuristic target.

Another possibly more realistic goal to advance renewable energy usage is through mandating portfolio standards for renewable energy in every state. Currently, about half of the states in the United States have a mandated percentage of a utility's energy load that must come from renewable energy sources. An easy way to increase the usage of renewable energy nationwide would be to mandate that every state enacts a minimum renewable energy threshold for their states to meet. The second half of this policy would be for each state to create a plan that increases this percentage year on year to eventually meet a goal of 80-100% renewable energy load in the future. This would keep the responsibility of the transition's speed in the power of the state, as state's rights are often a hot topic when transitioning historically state-specific powers to the federal government. The federal government would oversee these goals, but allowing each state to set these goals could make them more likely to meet them.

Consistent Government Support. A full-scale energy transition is a difficult process to undertake. It will require decades of consistent bipartisan support to ensure policies are not rewritten and new ones are consistently added. As mentioned in Chapter 4, this is often difficult to achieve. Changes in administration and the political party in power often result in new energy strategies that end up dismissing those of the previous administration. This is why it is crucial to view energy transition policies as beneficial to the interests of both sides – doing so could see Republicans and Democrats work together to see progress on this issue.

As discussed in Chapter 2, the OPEC oil embargoes of the 1970s led to America's first widespread energy transition policies. This happened primarily because both Republicans and Democrats agreed that America's energy security was an issue of national security, and reliance on foreign powers for energy imports made the United States susceptible to international pressure. While that is not exactly the case today, renewable energy policy does increase national security. Fossil fuels are a finite resource, and although it is not known exactly when the nation's supply of fossil fuels will run out, consistent depletion of crucial reserves will make extraction more costly. In this sense, renewable energy expansion could be seen as beneficial to national security as it creates an infinite supply of energy that does not require drilling deeper or in new locations, as does fossil fuels.

Historically, Republican policymakers have been the most opposed to energy transition policies. This is for a multitude of reasons, including having interests aligned with fossil fuel companies, being wary of the investment in unreliable technology, or in the interest of protecting their own investments. Conservatives are often concerned with sustaining economic progress, so framing renewable energy expansion and grid advancement as economically beneficial should secure more positive votes on these issues. Renewable energy has seen some of the largest year-on-year job growth out of any sector in the 21^{st} century, and this will only increase if the industry is expanded with energy transition focused policy. The policies mentioned above would also help decrease energy bill prices, representing another economic benefit of an energy transition. These advantages should be emphasized in any proposed policy to try to secure consistent bipartisan support.

In general, the United States needs a complete shift of thinking regarding its energy use. Most Americans do not understand the complex system that delivers them electricity, nor the threats facing the energy grid. Spreading the word and generating public support for these issues and policies is also a crucial step in achieving an energy transition, as it may help change the minds of lawmakers and possibly achieve some of the policies mentioned in this section. Any progress is good progress, and the road to an energy transition is unavoidably long and complicated. However, as with any just cause, it is worth fighting for.

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