The Effectiveness of Legislation on the Clean Energy Transition

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William Rimicci

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Pedro A. P. Francisco, Department of Engineering and Society

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Introduction

Clean energy will be a critical part of our electrical grid over the next several decades. It has seen surges and dry periods in the recent past, but there is no denying that it will continue to grow. Just in the last decade, the electricity generation from solar photovoltaic (that is, traditional solar panels) and wind, the two most common forms of clean and renewable energy generation, have both skyrocketed: According to the United States Energy Information Administration (EIA), solar PV electricity generation went from 8.4 gigawatts in 2014 to 123.6 gigawatts in 2024, an increase of nearly 15 times. Wind electricity generation went from 59.9 gigawatts in 2013 to 147.3 gigawatts in 2023, a nearly 2.5 times increase (*STEO Data Browser*, 2025). Without a doubt, clean energy is growing.

That said, the clean energy transition has also been a hotly debated topic in recent years. Politicians endlessly argue over whether or not it is truly important, people in power constantly pull back and forth on whether clean energy or fossil fuels are a better energy source (McDermott, 2025), and some even try to argue that the issue of climate change, one of the primary arguments for clean energy, does not really exist (La, 2024). It is clear that clean energy is a part of society in the United States that many people want to influence.

One way that we as a nation try to affect the clean energy transition is legislation. Laws regarding energy generation, transmission, distribution, and use are passed frequently in the United States, and they almost always make headlines in the news. Often, civic engagement and advocating for laws to be passed is cited as one of the best ways to make an impact on important issues like clean energy. The major question is: Do energy-related laws really cause concrete action on the clean energy transition, or is clean energy, as a relatively new set of technologies,

on a trajectory that is less affected by law? Additionally, if laws do have a noticeable effect, what kinds of laws are the most effective? What kinds of laws should we be trying to pass today?

By looking into the past, we may find our answers. Many laws regarding energy and electricity generation have been passed in the last few decades, beginning with the famous Clean Air Act of 1970 and extending all the way to the present, which means that there is plenty of data to investigate this question and find the leading precedent. An investigation of the energy-related laws passed in the United States from 1970 to the present, as well as their direct impacts (or lack thereof) on the progress of clean energy, reveals that laws do in fact have an effect on clean energy projects, especially those closer to the present day.

Background and Significance

Clean energy is good for our society in many ways. First and most obviously, it is better for the environment. The burning of fossil fuels to produce energy releases carbon dioxide, methane, nitrous oxide, and other greenhouse gases into the atmosphere (NASA, 2024). The light emitted by the sun, which is mostly visible light (380 to 760 nanometers in wavelength on the electromagnetic spectrum), can pass through these accumulated gases without much trouble and hit the Earth's surface, where they are absorbed. That absorbed energy is then radiated back toward space not as visible light, but as infrared (750 nm to 1 mm in wavelength). These lower-energy electromagnetic waves cannot pass through the greenhouse gases as easily, and instead are absorbed by the atmosphere. Some of the energy is then radiated into space, but most of it is returned to Earth, causing it to warm up and, as a result, having unnatural effects on the global climate. Clean energy does not cause the release of greenhouse gases, meaning it sidesteps the issue of climate change entirely.

Second, most clean energy is renewable, which means that we can never run out of it like we can with fossil fuels, which are a limited global resource. According to Our World in Data (2024), with data taken from the Energy Institute's 2024 Statistical Review of World Energy, there are 52 years' worth of recoverable oil and 45 years' worth of recoverable natural gas left globally at our current consumption rate. On the other hand, silicon, the primary ingredient in solar PV panels, is one of the most abundant minerals in the Earth's crust. It is also incredibly easy to find: Silicon can be extracted from silica, SiO_2, which is the primary ingredient in most of the world's sand. There are limits to the amount of energy we can generate from clean sources, of course, but they are not nearly as restrictive as the limits imposed by burning non-renewable resources like fossil fuels.

Third, clean energy is less expensive than fossil fuels. According to the International Renewable Energy Agency (IRENA) (2023), an intergovernmental organization with 170 members (including both the United States and the European Union), the average cost of solar PV in 2022 was 4.9 cents per kilowatt-hour, a third less than the cheapest fossil fuel, and the average cost of onshore wind in 2022 was 3.3 cents per kilowatt-hour, less than half the cost of the cheapest fossil fuel. The costs of these energy sources are projected to decrease further thanks to advancements in technology, while the cost of fossil fuels is expected to increase due to a diminishing supply.

Fourth, the installation of clean energy generation improves the national economy. According to the United States Department of Energy, "Around 3.5 million Americans already work in renewable energy jobs, and the renewable energy job market grew at twice the rate of the strong overall U.S. labor market in 2023." Innovating on clean energy technologies will also

place the United States on-pace with other countries in the market, keeping us economically competitive.

For all of these reasons, it is clear that clean energy is good for the United States and for the world as a whole, and that we should be keeping track of the major factors that might affect the clean energy transition. One of these major factors is, of course, energy policy. It goes without saying that laws in the United States have the potential to massively affect how society runs. However, the impact they have is not always so large. Standards and regulations can be poorly enforced, or they can be made more lenient due to lobbyist organizations. Economic incentives may be too small to be financially beneficial. Laws may be too narrow in focus to have a widespread impact. These possibilities mean that lawmakers in favor of clean energy must put even more care into how their laws are written so that they can have the best effect possible.

Methodology

To examine the effectiveness of energy-related legislation on the clean energy transition, I will be examining laws enacted by Congress in the past. I will start with the Clean Air Act of 1970, the first major energy-related law in the United States, and work forward through history to the present day. For each law, I will first look at the law itself and try to understand and interpret it in plain terms. Then, I will look for sources from around the time the law was passed and try to determine what the perceived effect on society was at the time. Finally, I will look for modern sources that discuss what the law's impact was in hindsight. With this information, I should be able to determine for each law whether things changed in a major way as a result of its passage, or if it was less effective than intended in some way, be it because it was not enforced

well, because it was not broad enough to have a real overall impact, because people found ways around the law, or any number of other reasons.

Historical analysis is a common technique used in the STS field, and it is certainly the most effective way to answer this research question. In matters of government and politics, precedent is often a very good predictor of future results. Political parties tend to act in consistent ways, judges make courtroom decisions based on past cases, and, on somewhat of a less optimistic note, Congress tends to take a long time to make important decisions and changes. These factors show that looking at outcomes of past government actions is an effective way of predicting the future.

In this examination, I will primarily be using the STS framework of the social construction of technology (Pinch & Bijker, 1984). This framework postulates that the technologies used in our society are moved, shaped, and developed completely by the values of the society it is used in. It is in direct opposition to technological determinism, which states that the path a technology takes to development is completely immutable and not affected by social factors.

In this case, the "technologies" that I am studying are those used in generating clean energy or replacing fossil fuels, such as solar PV panels, hydroelectric energy storage, electric vehicles, and others. I am viewing the "values" of society through the lens of legislation. While laws are not the perfect representation of a society's core values, they are the most well-documented and easily accessible representation. For the purposes of this paper, I am limiting my definition of "society" to just the United States. While there are certainly interesting conclusions to be extracted from studying laws and their effects on the clean energy transition

worldwide, and while there are certainly some international factors at play, a global perspective is beyond the scope of my research.

Literature Review and Discussion

Clean Air Act of 1970

The Clean Air Act of 1970 was the first major law related to energy in the United States. It covered many things, but its primary purpose was reducing air emissions, both from stationary sources, like power plants and factories, and mobile sources, like cars and planes. The law required these sources to reduce their air pollutant emissions to "the maximum degree [possible]," given the technology of the time, by 1975. To that effect, it created a new department, the United States Environmental Protection Agency (EPA), to help enforce the regulations. It also required each state to establish specific requirements (known as "National Ambient Air Quality Standards," or NAAQS) according to their individual industries, and it also required them to come up with a "State Implementation Plan" (SIP) to achieve the requirements (United States Environmental Protection Agency, 2024). While this law isn't in direct relation to the clean energy transition, it is the first major law that attempted to address the issue that non-clean energy sources cause: air pollution.

The enforcement of this act was met with significant resistance. For example: In some of the western American states, copper smelting was a major industry. The EPA suggested to those states that the sulfur dioxide emissions from copper smelting be reduced by 90% using capture technology. According to Noel de Nevers (1973), writing for the Scientific American, "the smelter operators began to protest. In each state they argued that the cost of the control measures was exorbitant and warned that enforcement would put the smelters out of business in that state,

forcing them to move to some other state with more lenient regulations." These arguments turned out to be successful, and several states reduced their regulations from those suggested by the EPA.

There was also resistance in the electrical power industry. The Clean Air Act specified that the regulations should be based on the "the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated." At the time, there were several technologies at the time that the EPA argued were adequately demonstrated, while the industry argued that they were not. For example: In the U.K., power generation facilities had been using technology to control sulfur dioxide emissions from their exhaust for 35 years, and this technology was easily available in the United States. The power industry, however, argued that power plants with the technology installed were "unreliable, expensive and troublesome to operate," and therefore that the technology had not been adequately demonstrated. These were not the only two disputes that occurred; debates like these two happened all over the United States as a result of the law (de Nevers, 1973).

Now, fifty years later, it seems like the Clean Air Act has been at least somewhat effective. Using Los Angeles, California, a city known for its poor air quality, as an example: According to a study by Erickson, et. al. (2020), "Before 1970, ozone concentrations [in Los Angeles] were above 600 ppb (parts per billion) and smog was very visible when the weather was right for ozone and smog formation." This concentration of ozone is well above the 70 ppb average regulatory limit set by the EPA. In recent years, however, this number has decreased significantly. According to the California Air Resources Board (CARB) (2023), the maximum

daily 8-hour average ozone concentration observed in 2023 was 80 ppb. Still above the EPA's limit, but far lower than concentrations observed before the law was passed.

A graph of the maximum daily 8-hour average ozone concentrations in Los Angeles from 1979 to 2023 is below in Figure 1. Unfortunately, CARB does not have data from before 1979, but note that even 9 years after the law was passed, the ozone concentration in Los Angeles was 0.24 ppm (or 240 ppb), well below the 600 ppb reported by Erickson, et. al., from before 1970.

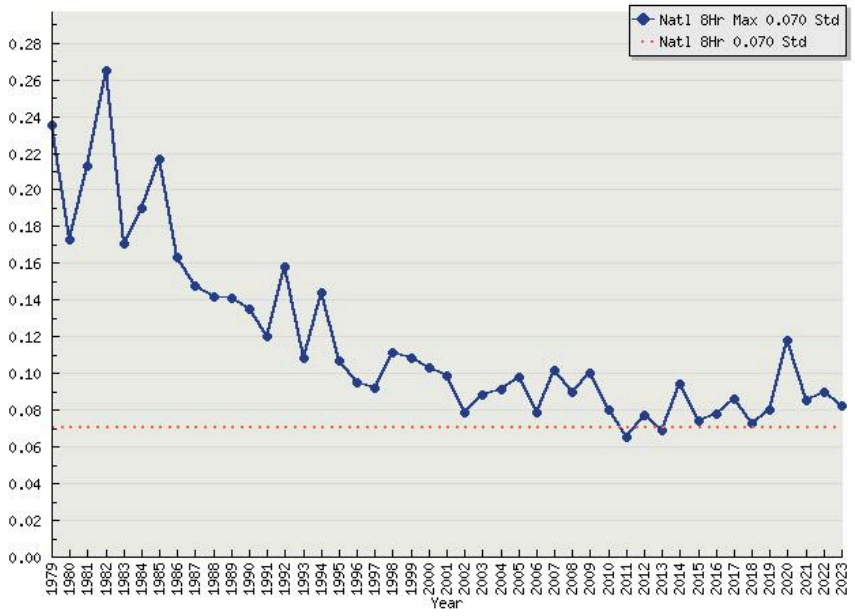

Figure 1. Maximum daily 8-hour average ozone concentrations (parts per million) in Los Angeles, CA, from 1979 to 2023.

While it is possible that there were other factors that led to the smog's reduction in California, it is likely that these efforts stemmed from the Clean Air Act. According to a report written in 1975 by the EPA's Office of Air and Waste Management and Office of Air Quality Planning and Standards, significant reductions in air pollutants were observed over the five years following the law's passage, in contrast to the years before, where no change had been recorded. Regarding ozone specifically: the report unfortunately states that there is insufficient data to characterize any trends in California, but given the decrease in other pollutants in the Los

Angeles area, such as carbon monoxide and nitrogen oxides, it is safe to assume that ozone decreased at around the same time.

Energy Policy Act of 2005

The Energy Policy Act of 2005 was another major law on the road to clean energy. It was also fairly diverse in its provisions, but one of its primary focuses, and the one it is remembered for today, was giving financial incentives to people investing in alternative fuel vehicles, like biodiesel (which, while renewable, is not strictly clean energy), hydrogen fuel cells, and hybrid electric vehicles. The law also incentivised alternative energy like solar, wind, and hydropower. These incentives were mostly given as tax credits and deductions to the adopters. The law also placed some restrictions on fuel use and energy efficiency, and it authorized quite a large amount of funds to be put toward alternative fuel research– $6.41 billion (U.S. Department of Energy, n.d.).

Around the time the law came out, it was expected to have little impact. Malmetal, et. al. (2007), in their presentation to the Institute of Electrical and Electronics Engineers (IEEE) Power Engineering Society, stated that the law would result in only small increases in solar PV, fuel cell, and hydroelectric generation, despite the law's many tax incentives for early adopters. This was mainly attributed to the size of the credits and deductions: the authors stated that they simply did not provide enough economical incentive to homeowners and potential generation investors. They also stated, however, that states with high electricity costs could potentially make such projects economical by adding incentives of their own. Regarding allocated funds, the authors stated that "it [was] unclear how effective [they would] be in increasing energy production."

Today, it appears that the Energy Policy Act of 2005 had mixed results regarding its impact on the clean energy transition. The bill was very broad, so there is no literature studying its overall impact, but there are some modern studies examining its individual provisions (though even those are rather minimal). For example: one of the sections in the Energy Policy Act of 2005 was about electricity transmission. It may not be directly related to clean energy generation, but erecting new electricity transmission lines and replacing old ones is a critical part to the clean energy transition, since our power grid will need to be more robust to handle the increased electrical supply and demand that will come from electrifying technology, like electric vehicles and manufacturing processes. According to Steven Ferrey (2024) in an article from the Vermont Law Review, "The Energy Policy Act of 2005 established an expedited process for the Federal Energy Regulatory Commission (FERC) to approve new electric transmission projects and to obtain all federal siting permits within one year." Unfortunately, this process did not see much success. Since the law was passed 20 years ago, only two locations have ever been identified by the Department of Energy as areas needing new transmission lines under this provision, and both potential projects were immediately overturned in court and shut down.

The act also provided incentives for alternative fuel vehicles (AFVs). Most notably for the clean energy transition, one of the AFVs that it incentivised was hybrid electric vehicles: it offered a direct tax credit to any consumer who purchased one before December 31, 2010. In a study by Alan Jenn, et. al. (2013), it was found that the act caused an increase in hybrid electric vehicle sales between 3% and 20%, depending on the model of car. They concluded that such incentives do impact sales in general, but only if they are big enough: incentives that are too small will not impact sales at all.

Inflation Reduction Act of 2022

The Inflation Reduction Act of 2022 was, according to the EPA (2025), "the most significant climate legislation in U.S. history" (United States Environmental Protection Agency, 2025) It instated tax credits and deductions for both individuals and companies looking to invest in clean energy technologies, and it allocated many billions of dollars to the US Loan Programs Office (LPO) to issue loans for clean energy programs. The law also created a the Energy Infrastructure Reinvestment (EIR) Program to "guarantee loans to projects that retool, repower, repurpose, or replace energy infrastructure that has ceased operations; or enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases" (U.S. Department of Energy, 2023).

We have yet to see the full effects of this law, as we are only two years from its implementation, but we have already seen some impacts, and studies expect them to continue to grow. In an article for the Journal of the Association of Environmental and Resource Economists by Brown et. al. (2024), the authors use several different models to predict the impacts of the law regarding the economy, the power sector, and public health (due to air pollution). After running their simulation, they found that the law would have a significant impact. They predicted that there would be a "large and rapid build-out of clean generation and storage technologies" resulting from the tax incentives, as well as a reduction in electricity price. In another study by Caballero, et. al. (2024), the authors predict that, due to the incentives on technologies like "weatherization, distributed energy generation, personal electric vehicles, heat pumps, and others," from both the Inflation Reduction Act of 2022 and the related Infrastructure Investment and Jobs Act of 2021, the United States could see up to a 40% decrease in emissions from 2005

levels by the year 2050 thanks to decisions made by individuals, like purchasing electric vehicles or installing rooftop solar.

Results

In investigating these three laws, it seems that legislation has the potential to impact the clean energy transition, but its degree of influence is highly dependent on the nature of the law. Laws instating standards and regulations, like the Clean Air Act of 1970, can be effective so long as the requirements are ambitious enough. We are still seeing the effects of that law today: the air qualities in metropolitan areas across the United States are *far* better today than they were before the law was passed over 50 years ago. Laws allowing tax credits and deductions can work, but the financial incentives must make investing in clean energy worth pursuing. If it still makes no economic sense to do it, neither individuals nor energy generation companies will invest in clean energy, even if there are some small tax benefits. Laws that allocate funds directly to clean energy projects through federal loans are very effective, because they attack the problem head-on and contribute directly to the clean energy transition.

The way these laws have impacted the clean energy industry is a perfect example of the social construction of technology (Pinch & Bijker, 1984). According to this STS framework, the general values of a society are what shape the technology developed and used in that society. In the context of clean energy policy: The citizens that make up the society of the United States come up with a set of values by electing congressional representatives and having them make laws. (Of course, laws are not a perfect representation of the overall values of a country, as different citizens will have vastly different views, but they are the closest thing we have to a nationwide set of values.) These laws, in turn, affect the technology used in our society: they

determine which technologies become more common and which die out, they encourage or discourage companies from developing certain types of technology, and they even influence what research is done to prepare for the next generation of technologies.

Conclusion

The clean energy transition is an incredibly important issue that we need to take seriously. Its success or failure will send ripples through the next century, affecting the lives of every single person living in it. As we continue to work on it in the coming years, instating policies that support its progress will be paramount to our efforts. A good way to determine what kinds of laws will be most effective is to look into the past. Looking at three critical energy laws, the Clean Air Act of 1970, the Energy Policy Act of 2005, and the Inflation Reduction Act of 2022, tells us that all energy legislation has some kind of effect, but the degree of impact varies depending on the nature of the law. To achieve the greatest impact, we should be passing laws that reward behavior from both individuals and corporate entities that progresses the clean energy transition, like tax deductions and other financial incentives. We should also ensure that these incentives are significant enough to make such behaviors economical. Laws instating regulations on carbon emissions and fossil fuels and laws providing funds to clean energy projects can also be an effective way to contribute to the movement.

We as a society have a lot of work to do on the clean energy transition, but we are not even close to being doomed, as many might have us believe. Looking at the past, it is clear that the work has already been started, and that it has been going rather well since its beginning. If we continue to advocate for change, and if we continue to do what we can to support clean energy policy, then our future, and the futures of those that will come after us, is bound to be bright.

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