

**Investigation into the Social, Physical, and Political Factors that Influence the Success of
Renewable Forms of Energy**

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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

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The modern world has been notably plagued by the effects of climate change. Such effects are manifested in natural disasters, the disintegration of critical biomes such as the ice caps, leading to rising sea levels and the submerging of sea level communities, increased public health risks from zoonotic transmission of diseases, major disruptions to existing food supplies, along with an endless host of other consequences (WHO, 2021). A primary contributor to such climate-related impacts is modern infrastructure (Mgbemene et al., 2016). When one imagines forms of infrastructure, they are typically thought to be what I call ‘the really obvious’ types: these are your transportation, your buildings both commercial and residential, and the manufacturing of commodifiable goods. But infrastructure also encompasses more discreet forms, ones we might not necessarily consider upon first glance. Examples of such are food supply – livestock production, agricultural produce, and additional means of production – and energy. This inclusion is crucial. The average reader can appreciate the significance of energy consumption, as the current discourse regarding the danger of fossil fuels is well known and established. To this day, they contribute to 75% of greenhouse gas emissions (GHG) and 90% of all CO₂ emissions (Climate Council, 2022), and therefore comprise a huge driver of climate change. However, understanding energy in a broader context of social and historical development provides critical insight into its continued evolution.

Coal, oil and other fossil fuels led the industrial revolution of the late 1800s and early 1900s. The development of the United States and industrial nations coincided with these energy production forms and thus, the very social, political, and cultural fabrics of modern society are enmeshed with fossil fuels. They are reliable, they are well understood, and inextricable from a nation’s politics. Yet, in the last few decades, renewable energy sources have emerged as robust alternatives to heavily carbonized sources of energy (Tierney and Bird, 2020). Installation of

these technologies has varied internationally, with disparities seen starkly between the United States, whose renewables comprise 12 percent of its total energy production (U.S. EIA, 2021), and other Western nations such as Switzerland, whose renewable energy sources supply almost the entirety of its energy needs (Zuttel et al., 2022). The question that remains is why. Why is there an observable disparity? Why do renewable energy forms enjoy more success in different nations? Science, Technology, and Society theorists have speculated that the success of these renewables is largely dependent upon the politics of the communities in which they are located (Winner, 1980). Scholar Langdon Winner summarizes these arguments that more democratized forms of government are inherently more conducive to decentralized forms of energy, insofar that the latter mirrors the basic structure of the former and vice versa, engendering congenial integration. Traditionally, carbonized energy sources such as coal, oil, and gas employ extremely centralized business models. Singular companies or suppliers are often solely responsible for production in a given region or country. Conversely, renewable energy presents ample opportunities for decentralized means of production, especially in the case of solar energy, as will be demonstrated from literature. This theory, on its own, fails to account for the lack of decentralized energy in the U.S., but large-scale solar energy on the part of China (Climate Council, 2022), the former of which is a democratic society and the latter generally communist. There must exist other reasons, which is exactly what I will seek to answer in this paper. In this paper, I will analyze an array of literary sources that focus on various implementations of renewable energies in an array of nations and communities, societal patterns along identity-based political delimitations, and theoretical writing on the sociotechnical underpinnings of renewable energy technologies and its success. I further consult statistical data from government agencies concerning energy generation metrics and demographic trends, as well as policy initiatives

pertinent to energy production, all with the express purpose of divining a reasonable hypothesis as to what societal, political, and physical factors influence the implementation of renewable energy. Initially when conducting research, I expected a clear causal link between gender and renewables success, but this connection was infeasible to establish. As I will elucidate throughout this paper, there are differences in gender participation that may have future implications for renewables, but the relative success of solar energy and other renewable energy forms can currently be explained through the variable access of communities to essential natural resources, and the presence of legal and political efforts within such communities to promote sustainability.

I. Literature Review

The literature examined for this paper can best be divided into three distinct categories. The first group of literature explores the analysis of gender in energy communities. From a demographic lens, gender plays a huge role in the extent to which citizens interact with energy systems. (Lazaroska et al., 2021). Many studies have found that female citizens generally participate far less in the energy production industries, across several Westernized nations. Lazaroska et al. conducted a case study of 11 solar ‘energy communities’ (EC) in Switzerland and discovered that the large majority of membership was men. It should be noted that the definition of an EC employed is “an umbrella term for different types of joint ownership of energy facilities, which is assumed to democratize decision making and the distribution of economic and social benefits of energy production” (Seyfang et al., 2013). This pattern was in spite of many members’ adamant perception that the ECs were thoroughly inclusive and did not promote discrimination in opportunities between men and women to participate. The authors also came to find that these observations held true in the UK and the Netherlands, indicating

consistency to gendered activity within ECs. Differences across gender lines were mainly attributed to a social association of energy production and its industry with masculinity. This societal association was believed to discourage female participation in existing energy-related activities and occupations, and furthermore prevented them from engaging in novel energy organizations like ECs.

The second group of literature discusses the natural resources a country has available to it that can better equip it for renewable energy usage, as well as other practices that promote its amenability to renewable energies. Data from the Climate Council asserts that many of the top renewable energy producing countries possess critical natural resources. One such example is Sweden, whose considerable access to water and biomass has catalyzed its ability to produce 50% of its total energy needs using renewables by 2012. Additionally, the country is projected to reach 100% renewable by the year 2040. Other European countries have followed suit, successfully relying on renewables for most, if not all, of their energy needs due to an abundance of natural resources.

The third group of literature focuses on the politics of the energy systems. As previously discussed, the idea of technological politics has circulated in sociotechnical and ethical discourse as early as 1980 with Winner. In summary, the success of an energy system is greatly influenced by its compatibility with the political structure of the community of interest. For example, a decentralized form of energy production such as solar energy will fare better in a democratic form of government than an authoritarian or centralized regime (Winner, 1980). Another aspect of the politics involves the possible contention that may accompany the use of new energy forms. To elaborate, climate change has become a profoundly polarized issue, in which citizens are traditionally divided along political lines. One case study assessed the politics of solar energy,

specifically the residential use of PV cells. Homeowners who possessed PV cells responded that there was inherent politics surrounding solar energy because solar energy is an “environmentally friendly technology” and is therefore wrapped up in the very politically tumultuous topic of environmentalism (Schelly, 2015). Public perception in this instance can be a huge determinant in energy outcomes, irrespective of the potential benefit for the communities at large. Indeed, some nations exhibit prior policies that lend themselves to other environmentally conscious practices. Literature in this area has found that environmentally conscious behaviors were more likely to lead to others down the road. This phenomenon, coined the spillover effect, related for example practices such as recycling led to an enhanced use of environmentally friendly modes of transportation. (Thøgersen and Olander, 2003). Communities in which environmental awareness is better established and heralded in their respective societies could therefore find the transition to decarbonized energy sources far more tenable and, thus, their positionality bolstered on a relative scale. Naturally, this also accounts for countries in which energy programs are already instituted, such as France where ‘sun sharing’ arrangements have been instated (Schmid et al., 2020).

II. Methods

In amassing adequate research for this analysis, I relied on two major forms of information. The first came from a substantial body of literature that was superficially discussed above. I classified the literature into three major categories that each offered partial explanations for the overarching research question. The categories emphasized the demographic, political, and physical factors that influence the extent of renewable energy implementation. I ensured that all

sources, aside from seminal papers describing relevant sociotechnical theory, were published within the last 20 years.

The second form of information came from statistical data about the relative composition of renewable energies in different countries. This data was analyzed in tandem with the literature to discern trends between characteristics of countries with comparative renewable energy composition. For clarity, composition is defined as the percentage of total energy output that is produced by renewables for a given entity.

Energy policies were also studied briefly for some European nations, but this brief analysis serves largely as supplemental information rather than its own distinct subset. The energy policies of these European nations served as comparative evidence to the United States in specific cases.

III. Analysis

Studying the development and prevalence of energy technologies within society necessitates a fundamental understanding of such technologies coevolution within their respective milieus. This is to say that actors external to technological viability and infrastructural capabilities play a substantial role in the expansion of renewable energy systems. This argument is predicated on the notion of the social construction of technology (SCOT), whereby societal factors and actors influence the very nature of the technology itself (Pinch and Bijker, 1986). Different relevant social groups construct shared meanings of a technology, where the proper use is motivated by their own perspectives, priorities, and interests. I believe this dynamic interplay between technology and society can reinforce existing power structures in society if the

technology fulfills a necessary good. Energy is a prime example of such a phenomenon. In much the way previously described, energy has burgeoned as an essential good over the course of history, instilling a reliance interest by society (T. Energy, 2021). The reasons for this are twofold. Firstly, when a technology, such as a new method of energy generation, is created, it is often expensive, limiting its access primarily to the wealthier echelons of society. Through the lens of SCOT theory, this would in turn restrict the groups of people who are actively influencing the continued use and development of the technology. It logically follows that these wealthier individuals are thus able to exert a unique influence over the technology in how it navigates its remodeling process, at least until it can be greatly reduced in cost or somehow provided en masse. This brings my analysis to the second reason, which is that because the interests of large swaths of society are barred from the coevolution process. The democracy-begets-democratized association asserted by Winner (1980) is undermined because there was never a true democracy with which to begin. Therefore, the socioeconomic elite translates into a continuous technological elite where the implementation of these technological systems favors the oligarchic structure from which it originated. Real world examples are how energy is generally organized in Western societies: large power plants or generative complexes that are traditionally organized into natural monopolies (Decker, 2015) who then have unilateral control of the energy's creation, handling, distribution, and cost. The sequence as described only accounts for exclusion based strictly on socioeconomic prowess, but important delimiters also include socially cognizable characteristics, such as gender expression. Gender is correlated with economic standing as seen in the gender wage gap where women make 84% of male wages for the same work (Fry, 2022).

In industries such as energy production, the work is frequently viewed as “masculine” and consequently discourages the participation of women in the workforce. Despite the lack of explicit barriers to entry – legislation or codified policy – there is de facto exclusion due to the way in which the industry of energy is perceived by female actors. We can see the disparity exaggerated even more when accounting for the fact that women make up about 39% of the global labor force, but only comprise 16% of the energy workforce, while earning 20% less than their male counterparts (IEA, 2023). Scholarship has demonstrated that the gender hierarchies present in current energy forms could likely pervade into renewables, if underlying social inequities are not addressed (Johnson et al., 2020). However, the missing link is whether those hierarchies have tangible impacts on the implementation of renewables. There is sparse evidence in this regard, but there is data to suggest that energy outcomes could fall along gendered lines in the political space. One study conducted in the US and Germany found that in the context of policy and legislation, female and male legislators exhibited significant differences in the energy policies and laws for which they voted (Fraune, 2016). Measurable differences among female and male decision makers make a case for the role of gender in renewable energy success, though the breadth of evidence would need to grow before drawing sweeping conclusions. Nevertheless, these findings underscore the importance in how gendered perceptions of energy can contribute to these differences: differences that have concrete implications for energy policy and, by extension, energy generation.

Beyond the relationship with gender, the physical resources at the disposal of a country contributes to its ability to generate renewable energy. Access to raw materials like biomass or water or even sun, all of which are determined by geographic location, can greatly enable a nation to more effectively harness renewable sources. Several studies have discovered a

negatively correlated relationship between natural resources and CO₂ emissions, predicting that the abundance of raw materials prompts greener initiatives in energy and reduced emissions (Azam et al., 2023). The notion that an availability of resources can precipitate investment in relevant energy forms is fairly intuitive, but the degree to which this occurs can be affected by prior energy needs of the community. An entity could possess renewable resources, yet lack enough to support substantial portions of the energy needs. Globally, energy demands still exceed the capacity of renewables (Tan, 2021) necessitating a continued reliance on fossil fuels. With certain countries such as the US, consuming disproportionately high amounts of total energy output (17% compared to the EU consuming 10.4%), the deeper dependence on non-renewables would be expected (Center for Sustainable Systems, 2021). The energy demand compared to European countries can further animate the disparity in renewable policy that's later discussed. Additionally, these metrics contextualize the differences in renewable energy production, as the US was not even included as one of the leading renewable producers compared to certain European nations.

The inception of technology in this case is constructed by the accessible resources, while the continued development can be beholden to broader social understandings of environmental protection and preservation. Through analysis of this relationship, SCOT theory appears in multiple forms: first in the societal conception of natural resource access, and second in the societal desire to prioritize certain resources over others. As social understanding evolves, so does technology. The limit to examining success through the lens of natural resources is that there are plenty of countries with an abundance of raw materials that lag in renewable energy initiatives (Biermann et al., 2022). It becomes apparent that the rest of the analysis hinges on policy choices invoked by individual countries and communities.

With social pushes for specific innovative directions, there follows a political atmosphere that permeates technological development. As detailed prior, very industrialized countries such as the US and individual communities can resist the implementation of renewable technologies due to the inherent political contention surrounding the environment (Nawrotzki, 2012). The downstream effects materialize in policy initiatives, statutory codification, and a jurisprudential framework that impedes the expansion of renewable energy. Pretty regularly, this opposition doesn't pertain to the efficacy of the renewable energy form itself, but merely the political issue it substantiates (Munro and Cairney, 2020). The social construction of what renewable energy means to society places handicaps on the technology and can bar further innovation, constituting a separate kind of social construction. The renewable energy form has new needs and new interests to accommodate, except this time they're ardent political beliefs that don't comport with technological benefits. Certain nations suffer more severely from sociopolitical obstacles than others, and can be seen through analysis of their political and legal systems. An easy poster child for the politics-gone-wrong category is the United States. Environmentalism and climate change have endured as controversial issues for years, and this has yielded huger barriers to large scale installation of renewable energy. It's worth noting that the involvement of the aforementioned carbonized energy elite in politics also perpetuates this reality, but that's a topic that demands more nuance and research to discuss further.

Policy and law have also reflected an investment in individualism in which citizens, corporations, and especially states can challenge the expansion of renewables and, more importantly, the regulation of fossil fuels, through valid legal pathways. These efforts are often upheld in long-standing legal jurisprudence as seen in multiple recent Supreme Court cases – *Massachusetts v. EPA*, *West Virginia v. EPA*, *Michigan v. EPA*. A noteworthy development from

this particular body of law is that generation shifting – the practice of prioritizing sustainable generation of energy over non-renewables – was proscribed by the courts, preventing the EPA from facilitating a wholesale inducement of companies to produce energy in this manner. This was irrespective of corporate capability to bolster renewable energy production.

Sociopolitical landscapes that actively oppose renewables to this extent are not observed nearly to the same extent in other Western nations. An example is Switzerland, who has comparatively ambitious renewable energy policies. The Swiss government, in accordance with their Energy Strategy 2050, has passed copious legislation promoting a shift to sustainable energy. Their strategy has emphasized domestic production through hydropower and other renewable resources, while placing legislative caps on total energy consumption (Swiss Federal Office of Energy, 2021). Conversely, countries like the United States have routinely passed policies that invest in harmful forms of production or provide suppliers with environmental exemptions (Hatzenbuehler & Centner, 2012). Moreover, lobbying is found to have significantly more undue influence on legislative outcomes than in European nations (Mahoney 2014), leading to accentuated obstacles to generation shifting initiatives. The stark differences across developed nations in policy can potentially explain the huge differences in percent energy distribution that comes from renewables, which heavily favors European nations such as Switzerland.

IV. Conclusion

The push for more renewable forms of energy is of paramount concern to the modern world. In many respects, this issue is the defining existential crisis of our time, inciting many developed nations to create goals of carbon neutrality within the coming decades. Renewable energy forms are continuously defined, adapted, and received by the societies in which they

exist. This means that forces far beyond the strict science of natural laws or phenomena can impact their success within countries who facilitate their implementation. These factors are intrinsically multifarious, amounting to political, social, and natural/physical circumstances in nature. Though the causality is inconclusive, there are gendered divides in participation and influence within solar energy programs and other renewable initiatives. A general lack of participation leads to a breakdown of the democratic correlation that would propel an increase in democratized energy. The natural resources available, as well as the political legal schemes, play a considerable role in the success of renewable energy systems, largely because of the ways in which physical and perceived construction of the technologies are altered, respectively. These findings establish a connection between three distinct social and geopolitical factors and the success of renewable energy systems, but more investigation into the directionality of this relationship deserves attention. While energy systems and technological instantiations can be governed by such factors, the reverse could be true, and establish an entirely new layer of inquiry into the intersection of energy and society.

To promote more robust renewable energy advancement, reshaping policy efforts must be paramount. Along with legislation aimed specifically at subsidizing energy forms and reducing emissions, peripheral efforts need to come to fruition as well. Some examples of these peripheral policy moves are restricting corporate involvement in political institutions and limiting energy consumption needs. By hindering corporate lobbying capabilities, large energy producers who utilize fossil fuels would experience a diminishment in their ability to perpetuate policy benefits and exemptions. Similarly, through curbing macroscale energy demands, the dependence on fossil fuels would be curtailed, as the supply burden of renewables would be more manageable and fossil fuels would be expected to cover the balance.

In all, the future of renewables is bright, but there is considerable work to be done before proposed carbon neutrality goals and environmental realities are realized.

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