Why Less Than 3%?

Integrating Solar Power into Existing Energy Systems, by Looking at Vietnam and the USA

(STS Research Paper)

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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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Introduction: Energy Sustainability, and its Importance

Frank Shuman from the *Scientific American* wrote in 1911:

> The future development of solar power has no limit. Where great natural water powers exist, sun power cannot compete; but sun-power generators will, in the near future, displace all other forms of mechanical power over at least 10 percent of the Earth's land surface; and in the far distant future, natural fuels having been exhausted it will remain as the only means of existence of the human race. (Jones, 2012, p.7)

Even though Charles Fritts made the first solar cell in 1883, it was not until 1958 that the launch of the first Vanguard I satellite made the ability to harness solar power by using photovoltaic (PV) cells a reality (Jones, 2012). Frank Shuman saw that the only future for the human race was in the complete application of solar power, yet that future has yet to be achieved. Solar power integration into energy systems has been lacking, and this paper will address the problem domain of solar power integration. A planet electrically powered by solar power alone is impractical, but Islam (2018) points out that with solar energy, "electricity demand of all Europe can be met by harvesting from only 0.4% of the Sahara desert." (p. 989). Islam makes it clear that solar power should be a significant player in the focus of the energy of tomorrow.

By the year 2050, the International Energy Agency (IEA, 2021) has set a goal in which 42 countries pledged to meet an energy CO_2 emission of zero. This goal is set to minimize the effects of global warming by eliminating the continual output of greenhouse gasses into the atmosphere, like CO_2, that drive the earth to retain a more troubling amount of thermal energy from the sun. The prediction by the IEA is that the world can keep the change in global temperature (since the industrial revolution) to a max of 1.5 degrees Celsius if a majority of the industrialized countries can achieve an energy network that produces zero emissions.

Low-income countries are an important concert to the IEA goals for renewable energy. It is critical to note that high-income countries produce most air pollution and are in a late stage of energy development. As discussed by Coyle (2014):

> In recent years China has surpassed the US as the world's largest emitter of greenhouse gasses. China, US, the European Union, Brazil, Indonesia, Russia, and India account collectively for approximately 60 percent of emissions… More than 75 percent of carbon dioxide emissions derive from the burning of fossil fuels, principally coal, oil and natural gas. (p 3-4).

At first glance, it would appear that when addressing environmental pollution, the main focus should be on late-developing countries. However, developing countries will inevitably become major consumers of electricity, with large populations that will become a future middle class. It is a common misconception that solar energy is a technology advanced energy source that needs a technological advanced nation.

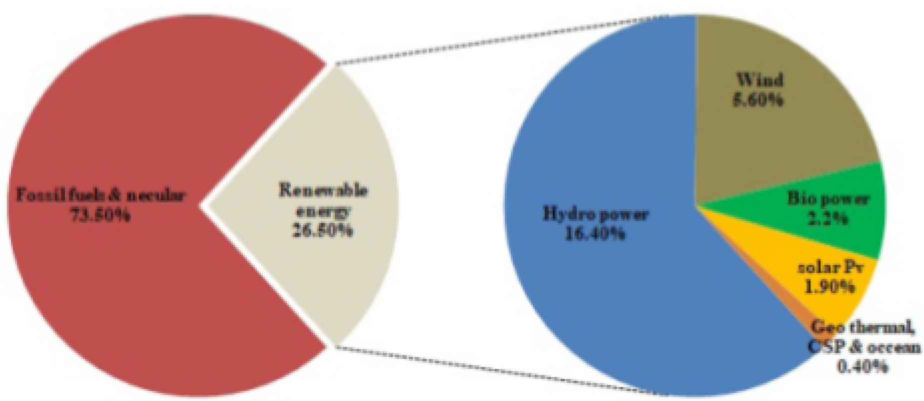
This paper addresses the socio-technical system (STS) that encompasses the integration of solar power in existing energy systems by first looking at its technical/geographical, political/policies, and economic limitations. To prove that solar energy is a realistic energy source for low-income countries an approach similar to other STS reports is used. A methodology inspired by Wiebe Bijker will be utilized to give better understanding to the issues of the STS between developing and developed countries with the aim of determining if developing countries have a role to play in the field of renewable energy.

Problem Definition: The Issues of Incorporating Solar Energy into Existing Energy Systems

The global energy and environmental crisis drives humanity to commit to renewable energy, with solar power being the most promising (Elon Musk, 2013). One would think that solar power would be one of the primary sources of renewable energy production in the world. Qazi's review on sustainable energy in figure 1 estimates that only 27% of global electricity production is renewable and that only 2-3% of that renewable energy is from solar photovoltaic (PV) cells and concentrator solar power (CSP) systems (p. 63841, 2019).

Figure 1

Estimated Share of Global Electricity Production



Note: Estimate from a collection of over 42 papers renewable energy studies by "Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions" (Qazi, 2019, p.63841).

The estimated global power production has less than 3% solar energy. Most renewable energy is in the form of wind and hydroelectric power. In total only 27% of the world's electricity comes from renewable energy. Solar power is only a small fraction of the earth's current electricity production.

What is known about the problem domain, the issues of incorporating solar energy into existing energy for any country, can be broken down into three categories: economic, political, and geological/technical. The economic impact of introducing solar power into energy systems is heavily determined by the amount of production and research investment in the field of solar energy the country has, as Nguyen points out," renewable energy projects tend to require advanced technology with relatively high costs, which must be a huge burden for national budgets." (2019, p. 1055). Ngyuen's review on energy consumption around the world shows that low-income countries at the early stage of GDP development have an increased reliance on non-renewable energy with hydrocarbons, while in later stages of development, a country will take into consideration environmental pollution and tend to switch over to more renewable energy.

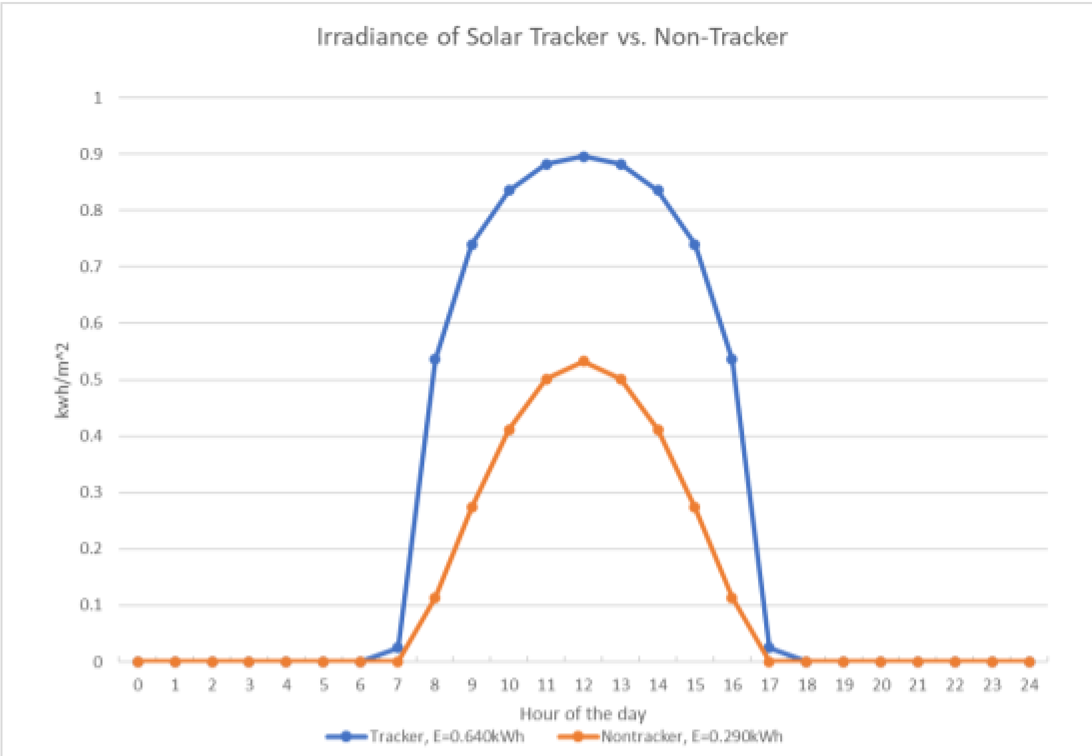
Solar energy currently comes in two primary forms, concentrated solar power (CSP) and Photovoltaic (PV) cells. CSP systems are used for only industrial level energy production and use thermal solar energy. They often use arrays of mirrors that turn heated water into steam to run electricity-producing turbines. CSP can span more than a square kilometer and are often built in deserts. The more common PV cells can be placed anywhere with direct sunlight and can be a variety of sizes." PV cells convert solar radiation directly into electricity. When photons of sunlight strike the cell, electrons are knocked free from silicon atoms and are drawn off by a grid of metal conductors, yielding a flow of direct current." (Jones, 2012, p. 12).

The first hurdle in implementing solar energy into power infrastructure is the production costs of building CSP systems and producing PV cells. In the past, renewable energy has been more expensive than non-renewable, "Renewable energy technologies show low operational costs and extensive lifetimes, in trade of high investment costs." (Haas, 2018, p. 403). This is especially true for CSP systems which need a lot of upfront financial investment and heightened maintenance. PV cell costs differ depending on the country they are produced in; PV cell production is cheap in countries like China, Germany, and the United States (Behuria, 2020, p. 4). The cost discrepancy in PV cells is due primarily to their governments' technological investment putting considerable amounts of subsidies and money into more efficient solar panels for a cheaper cost. Lastly, large counties with access to deposits of rare-earth metals and a cheap labor-force further decrease the economic costs.

The last economic factor is the issue of high-quality electricity. Solar energy lacks high power electricity, with power output that is never consistent. Solar energy requires the presence of sunlight; solar energy production is high during the peak hours of the day and negligible during the morning and night. The solar irradiance trend is shown in figure 2. The time of day impacts solar energy's quality, time of year, and weather. The winter months will have less daylight, and cloud coverage will lower energy production. This impacts electricity market prices enormously, especially when energy demand is not directly related to solar energy output. The behavior of solar energy makes it hard to be a primary source of energy with its lack of high-quality electricity; as Kumar (2019) voices, "In short, access to solar energy does not replace existing traditional energy use but operates somewhat intermittently alongside these alternative forms "(p. 172).

Figure 2

Irradiance at Different Hours



Note: The predicted irradiance of a full solar tracker vs a flat solar panel facing directly at zenith. The irradiance is showing the rough estimate of the radiation each case would yield. Discussed more in depth in my technical thesis report (Created by Author).

Solar power has come a long way in research and development to the point where only a tiny fraction of the Earth's land mass would be needed to power all of the Earth's electrical needs (Islam, 2018, p. 3). Still, there are some technical shortcomings of solar energy. As mentioned earlier, solar energy currently needs to have a large-scale system of energy storage to be used viably. There are two main methods of energy storage: gravity and chemical batteries. Gravity batteries function by harnessing the power by storing excess energy in the form of potential energy by pumping water to a lake on top of a hill, then releasing (like a dam) to generate energy from kinetic energy, flywheels can also be used similarly. Chemical batteries cannot be used everywhere; they often need locations with large bodies of water at high elevations. There are chemical batteries that have reactions between materials that allow charged particles to move to store and release electricity. In recent years, chemical batteries have had considerable innovation, but they are often made of harmful elements that pollute heavily during production and disposal. Energy storage is a central technological leash on the future of renewable energy for it to overcome the advantages of hydrocarbon's flexible, high-quality electricity, "Energy storage remains a strategic need that can enable renewable energy generated from intermittent sources, and one where innovation, investment and multi-stakeholder dialogues are in great demand." (Coyle & Simmons, 2014, p. 286).

Geography has a very notable impact on the practicality of solar power. CSP systems need a great deal of land, usually being built-in expansive deserts where there is a lot of sunlight and land far from human dwellings. CSP plants are viable in counties with plenty of flat sunny wasteland, like the US (Shum, 2017, p. 462). China also has a large amount of land that can be used for solar energy generation, "China has abundant solar energy and largely available wasteland, especially in the West and the North. The condition is very suitable to construct CSP plants" (Hou, 2009, p. 4). PV panels can be implemented both on a large industrial scale and a small domestic scale; PV cells can be used in large solar farms or on rooftops in suburbia. Both CSP and PV cell power production is directly influenced by greater latitudes and altitudes, with longer days and more direct sunlight.

The last known factor in implementing solar energy into existing energy systems is the organizations and policies that evolve around it. Renewable energy usage in a country is often more popular when a government puts money and resources into it. This attention often comes from incentives to power companies to develop cleaner power networks or taxes on carbon emissions. Governments can also help fund research in renewable energy that can trickle down to improve the overall feasibility of clean energy. Public opinion also needs to be taken into account; alternative energies have been held back from taking off due to public opinion. Nuclear energy during the '70s was seen as the future for solving all our energy needs, not just for power plants but also for cars, planes, and space travel. Currently, nuclear energy is only used on any significant level by Japan and France, with much of the rest of the world being wary of it, with nuclear power being lumped in with fossil fuels as "environmentally destructive" (Harjanne, 2019, p. 335). Solar power does not have the same issue of being seen as environmentally destructive, but it is put too high on a pedestal. This often leads to poor implementation of solar energy systems that are more done for political sway than for long-term development, making solar energy used only when convenient.

The unknowns that will be addressed in later sections will be as to why some countries use solar energy more than others, with a focus on cultural factors that might be holding them back. Another unknown is determining whether solar energy requires a developed country in order to be a viable energy source. The last unknown is whether solar power should be treated in perspective of the global environmental and energy crisis.

Method: Compare and Contrasting Solar Power in Developed and Developing Countries

Bijker's article (2007), American and Dutch Coastal Engineering: Differences in Risk Conception and Differences in Technological Culture, compares the United States and the Netherlands coastal water overflow protection system. The author analyzes why the United States (US) approach to flood risk differs from the Dutch. Bijker provides this comparison by analyzing two separate papers on coastal engineering from the two countries. Bijker includes the history of coastal engineers in the two countries and risk tolerances in theory systems. He also compares their approach to technological culture and engineering practice. Technological culture can be defined as the human behavior, values, and trends that emerge alongside technology. The purpose of Bijker's paper is to provide a foundation for identifying the shortcoming and possible paths for improvement for US coastal engineers in its goals to better protect their citizens from a natural disaster similar to Hurricane Katrina.

The technological culture in Bijkers work observes the difference in the histories and societies of America and the Netherland’s.

> differences between American and Dutch coastal engineering styles are related to the differences between American and Dutch societies, or rather technological cultures.10 It would be a standard STS point to stress that the development of a national style of coastal engineering is related to the national society and culture. (2007, p.7)

Bijker's look into technological cultures finds issues and solutions to technological problems that would have been missed. It is essential to prove solar power's role in developing countries, and this methodology will give a better perspective.

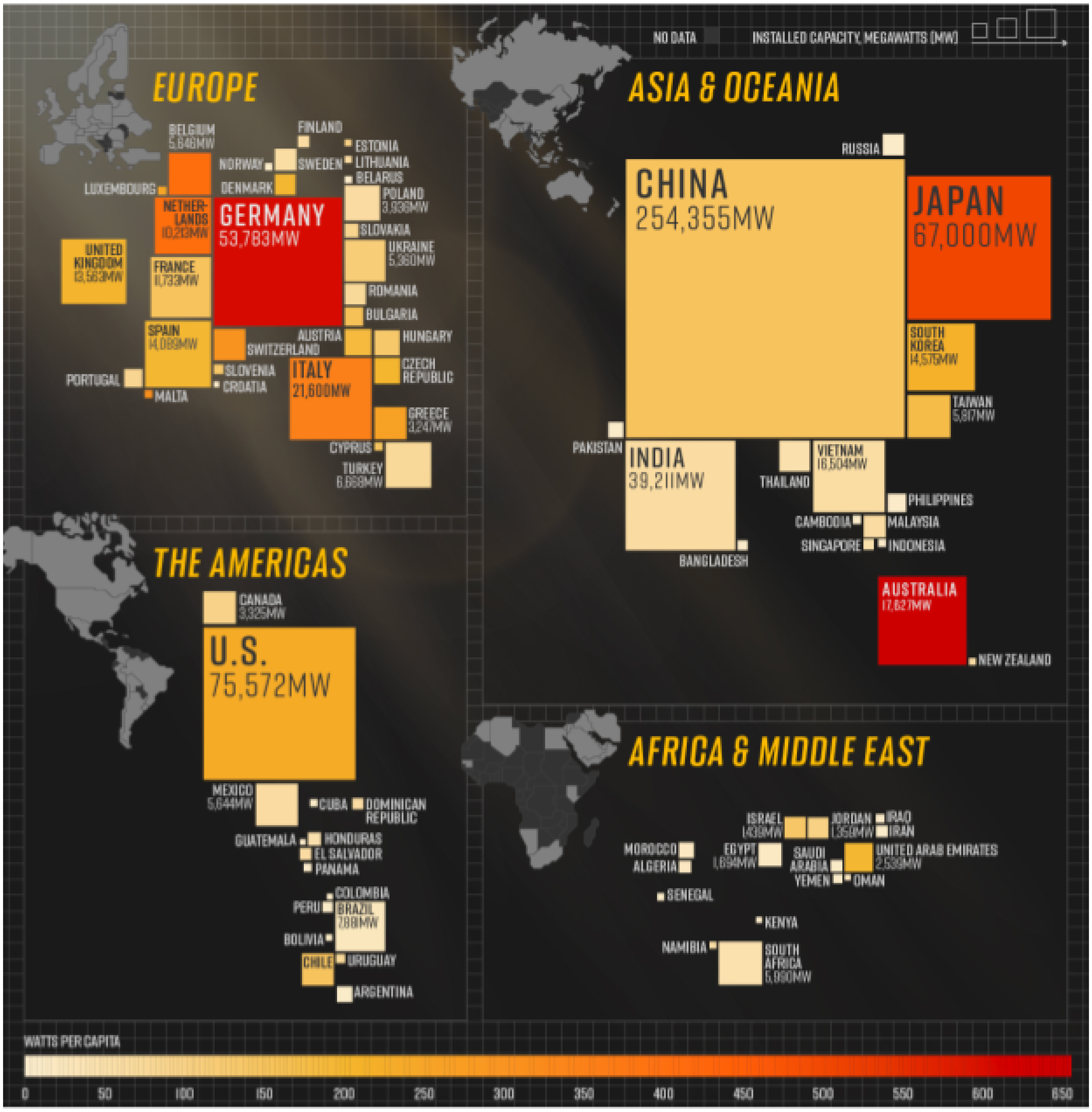
Bijker's method, of addressing coastal engineering concerns in the US, can be used to help determine what is holding back developing and developed countries in implementing solar energy, and whether developing countries can effectively implement solar power. Comparing two very different nations will offer new insight into how we can best push solar power forward, both in developed and developing countries. While this paper will not be comparing two specific articles, it will be comparing the US as a developed country to a developing country, Vietnam, based on a collection of papers. The approach will be less focused on the engineering practice and more on the technological cultural differences between them when it comes to their solar power infrastructure. The method will follow the approach in the last section with the three main categories of the problem domain: geotechnical/technical, political, economic. Instead of following the same methodology of Bijker, focusing on the differences in risk conception and technological culture, this paper's methodology will be differences in foundations and approaches in integrating solar power into national power grids. It is important to note that Bijker mentions his method is not a comparison of promising versus inadequate approaches, where one country is better than the other. All countries have something to learn from the other (Bijker 2007, p.6).

In researching for this paper, there was lots of focus on solar energy for only a handful of countries compared to the United States. China, Germany, and Japan were common countries used to compare innovations in renewable energy. In Figure 3, you can see why many papers focus on these countries on the topic of solar energy (Bhutada, 2021). All top countries are technologically advanced and have a healthy middle class. Vietnam is less than the US when it comes to solar energy production, but it is quickly becoming renewable energy's most enormous enthusiast since 2015 (Riva Sanseverino, 2020, p.2).

Comparing the differences in technological approaches for two very different countries, Vietnam and the US, may seem odd, but fresh ideas and conclusions require unique connections. The more distant the connection between STS is, the more informative they are. Vietnam may only have one-fourth of the solar energy production as the US, but it outproduces even some developed countries. Vietnam is less than the US when it comes to solar energy production, but it is quickly becoming renewable energy's biggest enthusiast since 2015 (Riva Sanseverino, 2020, p.2). This method will attempt to disprove the relationship between technological advance countries and solar power integration.

Figure 3

Solar Energy Production, World Wide



Note: The above infographic uses data from the International Renewable Energy Agency (IRENA) to map solar power capacity by country in 2021. This includes both solar photovoltaic (PV) and concentrated solar power capacity (Bhutada, 2021).

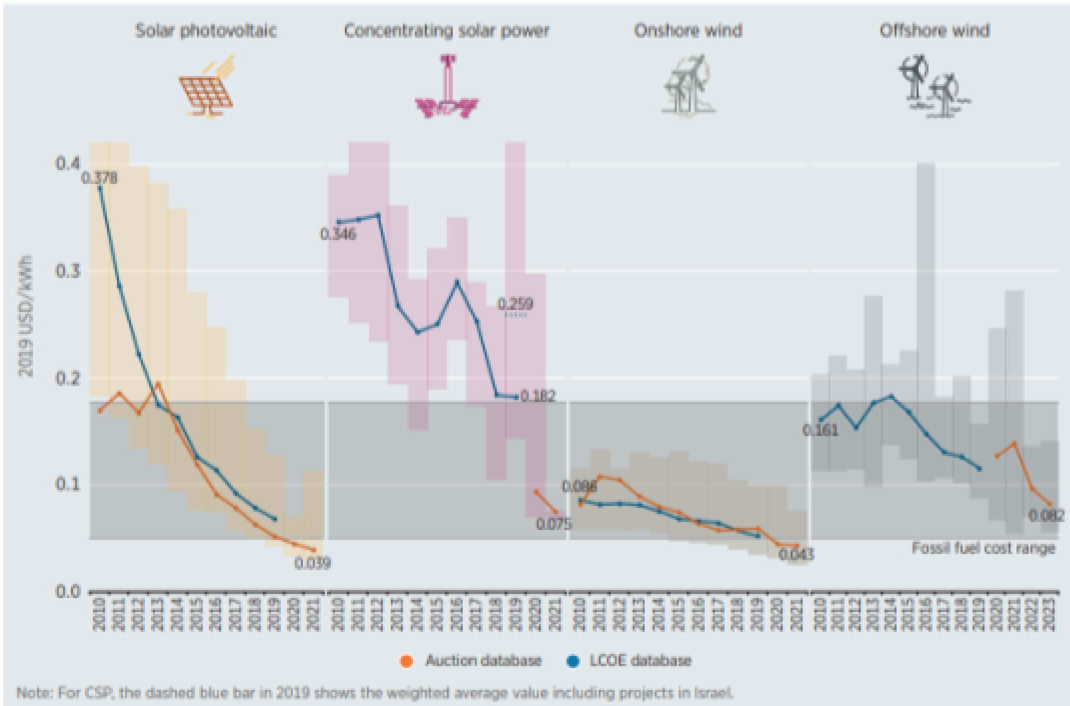
Results: Compare and Contrasting USA's Solar Power's Technology Culture to Vietnamese

A Vietnamese's View

Without getting too deep into Vietnam's rich and complex history, Vietnam is not a true democracy but a Marxist-Leninist one-party socialist republic that has been slowly changing through constitutional amendments and movements to become a relatively centralized socialist republic (Duiker et al., 2021, Government and society section). Its Prime Minister oversees the approval of any power development plan proposed by the Ministry of Industry and Trade (MOIT) (Riva, 2020, p. 15). Vietnam has a faulty educational system that tends to favor the rich heavily and offers a very sparse amount of technological research and development, having only 10% of people 25+ having at least a bachelors or equivalent compared to the USA's 40% (The World Bank, 2022). The lack of technical research and development leaves the country reliant on imported solar power projects and equipment, with no institution for solar energy research (Riva, p.20). Vietnam's mean income level is only around 3,000 US$ to US's 65,000 US$ (The World Bank). This makes Vietnam a developing country with a small middle class. Electricity is mostly only available in major cities and is viewed as a privilege given by the government, Though Vietnam has recently seen a huge growth in solar energy usage. This has been largely contributed by the lower of the installation and upkeep cost of solar energy recorded by the International Renewable Energy Agency, look to figure 4 (IRENA, 2020, p. 14). With Vietnam's cost of PV electricity dropping 55% since 2015 (IRENA, p. 72), investment into renewables has become more competitive.

Figure 4

Global weighted average LCOE and Auction/PPA prices 2010-2023



Note: The thick lines are the global weighted average LCOE, or auction values, by year. The grey bands that vary by year are cost/price range for the 5th and 95th percentiles of projects.. For the LCOE data, the real WACC is 7.5% for OECD countries and China, and 10% for the rest of the world. The band that crosses the entire chart represents the fossil fuel-fired power generation cost range (IRENA, 2019, p.14).

As a developing country, Vietnam has, in the past, relied primarily on fossil fuels with a sparse amount of hydropower, as discussed by Riva Sanseverino (2020). "Like other developing countries in Southeast Asia, the renewable industry in Vietnam is still in its initial phase. By 2018, the energy development path in the region has largely relied on fossil fuels like coal, oil, and natural gas." (p.2). Vietnam is not as geographically diverse as the US, and it has only a small fraction of the landmass, lakes, extensive deserts, and open plains of the US. Vietnam is mostly covered in tropical forests with an extensive mountain range running down the spine of the state. Due to the tropical nature of Vietnam's environment, flooding and tropical storms are a constant factor in expanding its infrastructure. However, its proximity to the equator and average land altitude is perfect for solar power generation," Vietnam has abundant solar energy sources, as the country has hours of sunlight varying between 2000 and 2500 hours annually" (Nguyen, 2019, p. 64). The infrastructure of Vietnam limits its usability of solar power, "Many areas have high potential, but implementing extensive solar power resources is difficult due to weak infrastructure (roads, railways, power infrastructure, and supply, etc.)" (p.19). The lack of infrastructure means more need for off-grid power, making PV systems more desirable.

The overall motivation for Vietnam to pursue renewable energy, like solar power, so aggressively is due to four main factors: government commitment to energy availability, public demand for clean air, solar and wind lobbying, and government commitments to iteration climate change treaties (Do, 2021, p.4). The Vietnamese government is very committed to increasing its energy production with the Prime Minister's consistent message being to not let electricity shortages happen again. The government has also recently taken action in renewable energy policies, "In 2020, Vietnam adjusted its nationally determined contribution (NDC) to commit to reducing greenhouse gas emissions by 9% or 27% in 2030 relative to business as usual without and with international assistance, respectively (Government of Vietnam, 2020)." (Do, p.4). Vietnam has also been overtaking a lot of its neighbors when it comes to fossil fuel subsidy reductions, as is mentioned by Do (2021): "Its annual reduction in fossil fuel subsidies in 2019 was 56%, while those of Thailand, Indonesia, and Malaysia were 50%, 43%, and 12%, respectively" (p.8). Fossil fuels have also recently been hit in 2020 with a passed law on environmental protection which legalized an emission trading scheme, a form of carbon tax.

It is also noted that Vietnamese cities have a huge air pollution problem due to their power plants being located within their cities. This means that citizens are more visibly impacted by greenhouse gas emissions from fossil fuels due to the health issues that they have to deal with. Additionally, the land itself causes even more concern, "As one of the world's most vulnerable regions to climate change… estimated to be on track to experience a mean sea level rise of as much as 70 cm, a decline of up to 50% of rice yield potential, and a loss of 6.7% of annual GDP by 2100." (Do, p.7), this means that citizens' livelihoods are at direct risk from carbon emissions.

A United States View

Looking next at the United States of America (USA), the USA is a multi-party republic that has semi autonomous states. These states often have their own agencies, policies and goals when it comes to the environment policies, as shown in table 1 in a paper by Aslani (2014, p. 156). The US has a less centralized government than Vietnam, giving it less control over regulating environmental concerns.

Table 1

Renewable portfolio standards in five selected US states.

State	Selected program mandate
Connecticut	- RERs should account for 27% of sales by 2020, - The State's Clean Energy Finance and Investment Authority is responsible for creating an investment program for 30 MW residential solar installation,
Illinois	- 25% of sales from renewable sources by 2025 for large utilities,
Maryland	- 20% of sales from renewable generation by 2022, - Designation of waste-to-energy facilities as qualifying to meet the 20-percent target beyond 2022, - Solar sources account for 2% of electricity sales by 2022,
Texas	- 5880 MW RE utilization by 2015, - 500 MW of renewable capacity other than wind,
Washington	- 15% of sales from the State's largest generators must come from RERs by 2020, - The administrative penalty of 5% per KWh for noncompliance.

Note: Each state has their own programme mandate for the environment, in addition to what policies the federal government implement (Aslani, 2014, p. 156).

The people of the USA have a culture with a strong sense of individual rights and freedoms. USA's culture is a positive thing when it comes to social justice, but not as much for solar power. Looking at California, 90% of the residents support large-scale solar power, but those remaining 10% are the most vocal citizens (Moore, 2016, p. 68). With the United States cultural outlook on individualism and freedom, a very small percentage can have a dramatically harmful effect on the pursuit of integrating solar power. When approaching a global issue, like the environment, strong individualism can easily become disadvantageous.

In addition, the citizens of the US often suffer from "NIMBYs" (not-in-my-backyard): a selfish sense of emotional attachment to a place. In some cases this is justified as a response to “energy sprawling” in figure 5, like in the construction of the CSP Ivanpah Solar Electric Generating System (ISEG) in California (Moore, p. 72). The ISEG was a CSP system built in 2013 in the Mojave Desert. During the construction of the large-scale solar power farm, it only took a few citizens to force considerable delays over the entire project. While it may not be malicious, US citizens have a tendency of opposing large industries if they are impacted by the infrastructure’s function or appearance.

Figure 5

Solar Energy Production

Note: Basin and Range Watch Cartoon depicting "energy sprawl" in reference to the Ivanpah ISEGS case. A political illustration of the construction of large scale renewable energy power plants, in response to the construction of the CSP planet in the Mojave Desert (Moore, 2016, p. 72).

The people of the US are used to having their power plants placed in locations where they cannot see them, often locating them far away from cities. This leaves a pattern of "out-of-sight, out-of-mind" as mentioned by Sovacool.

> Suggesting that the environmental costs of electricity are far less than they actually are… As distance, technology, and an urbanized lifestyle come to cushion Americans from the direct environmental costs of energy, they become increasingly less aware, and eventually less tolerant, of the intrusions of energy development on our personal space. (Sovacool, 2009, p.367)

Sovacool shows that the comfortable lifestyle that Americans live in has in a way shielded them from the major issues of the world. In Vietnam, for example, pollution and waste are more noticeable due to Vietnamese power generation and waste treatment being more centrally located in urban areas.

Looking at the technological culture behind the US, in the eyes of liberty and freedom, solar power often seems democratic if it is not impacting a citizen's daily life, or if it is small-scale and distributed. An example of issues integrating renewable energy from Moore (2016):

> A local farmer whose property now abuts the construction site of a 550 MW, 4000-acre large-scale solar PV power plant said that solar developers offered her "[solar] panels of silence" meaning that the panels would buy her silence—that she would not stage a highly visible public protest against the project (p.75).

Solar panels, on the other hand, that are installed for personal economical benefits, on homeowner’s roofs, are seen as much more desirable because the owner gets more than the environmental benefits of his/her PV cells. The home owner’s perception is caused by the remains of the “manifest density": a vast land of opportunity where taxes are few and land ownership is plentiful. People in the US value land and privacy immensely, and may be more inclined to resist government projects.

Americans tend to complain about solar power, but they are also naive about the amount of electricity they consume. Ever since America entered the post-industrial age, where they were identified by their purchase products (consumption communication), they have slowly become one of the worst producers of waste and consumers of electricity. Americans' self-centered lifestyle places one's personal needs above that of the environment. It is also worth pointing out that many Americans may simply forget about how important electricity is as a foundation for development. With so many new or exciting innovations in science and technology, their dependency on more fundamental technologies, like electricity, can easily be overlooked. Socacool's (2009) paper has sociologist Paul N. Edwards remarking:

> The most salient characteristic of technology in the modern (industrial and postindustrial) world is the degree to which most technology is not salient for most people, most of the time . The fact is that mature technological systems cars, roads, municipal water supplies, sewers, telephones, railroads, weather forecasting, buildings, even computers in the majority of their uses dreside in a naturalized background, as ordinary and unremarkable to us as trees, daylight, and dirt. (p. 367)

In Vietnam, electricity is viewed as an innovative technology and sometimes even a comontity. In the US, electricity is viewed as a basic need.

The US government puts a lot of funding into their research institutions, hoping that it will drive technological leapfrogging and more efficient forms of renewable energy (Reddy, 2012, p. 222). As a result, the US has some of the most innovative solutions in solar energy and the most advanced CSP systems, such as the Ivanpah Solar Electric Generating System (ISEGS) in California. This is all well and good, but US culture puts a greater importance on research and innovation over application and installation of renewable power, for in their eyes this is more respected. Vietnam's government struggles to find financial resources to subsidize and develop renewable energy, but with the rapid decrease in solar power installation cost shown in figure 4, solar power can be seen as a very competitive alternative to fossil fuels (IRENA, 2020, p. 14). The upfront economic investment is still higher than coal, but it is predicted to be a better investment (Haas, 2018, p. 403). Both countries use subsidies as incentives for companies, and carbon taxes or emission trading schemes (Do, p. 9), to help promote more usage of renewable energy.

Takeaway From Comparison

The takeaway from the comparison-based methodological approach leaves some new insight into what is holding back and accelerating solar power in both a developing country and a developed country. In order to improve solar energy production in the US, changes in the commitment to renewable energy need to be adopted. Citizens need to prioritize saving the world over their individual rights and become more educated about the energy they consume. In Vietnam, their lack of individual freedom of expression means that the government is the main factor in solar power. However, the government of Vietnam needs to invest in the research of renewable energy to encourage solar power independence and invest in better electrical infrastructure that can handle the expansion of renewable energy. On the other hand, the US government needs to focus on integrating renewable energy and less on the idea of technological leapfrogging. Americans are very open to the idea of solar power but are, surprisingly, not open to its integration. Both governments could do with more incentives for the integration of solar energy, focusing on corporate incentives and taxes on carbon footprints.

Vietnam's push for renewable energy is new and hopeful. This research has shown that even developing countries, which still struggle just to keep the lights on at night, see solar energy as a viable future. With the right government and social interest in alternative energy, even poor countries without much new innovations can benefit from alternative forms of energy, like PV and CSP systems. The biggest hurdle for Vietnam seems to be the lack of experience with solar power and the shortcomings in their current power infrastructure.

The method and results show that government social involvement in renewable energy is significantly important for any country. The US has all the means to implement solar power on a larger scale, but it is often held back by a lack of government involvement and citizen commitment. The most substantial technological roadblock seems to be the need for a flexible large-scale energy storage system. In a developing country, like Vietnam, time and education are sizable hurdles to their electrical power development. Even with the lack of education and the struggling economy, the Vietnamese have shown that early-stage countries have a greater role in dealing with both CO2 emission and renewable energy. In the past decade, solar energy has advanced to the point where even nations with small economies can afford and justify solar energy as a serious alternative power source.

Conclusion: Solar Power Viable for a Developed and a Developing Country

The central claim is that solar energy is a valid option for developing countries. A country does not need advanced technology to integrate solar energy into existing energy networks. A country's ease at integrating energy is not as dependent on economic and technological factors as the people and groups that make up a country. Technological culture has a much larger part in the practicality of solar energy in a region when looking through STS; the government and the people under them must be committed to renewable energy in its practical application.

It is worth noting the limitations of this paper’s method of approach. The analysis only focuses on the technological culture of two countries, and does not deal with the individual governmental policies and economic options available to them. Also, it is not accurate to assume that the US represents all developed countries and Vietnam represents all developing countries;

each country has its own cultural and societal problems to address. Lastly, the method does not make connections between different actors, technology, organization, and people.

Other renewable energies, that were not focused on in this report, will be better suited for different locations and offer a lot of the same vices/deficits—the failings in the integration of solar power mirror that of wind in many cases. Technology should be viewed in its practical application by looking at the technological culture that surrounds it. More analysis of developing countries using this thesis methodology should be taken to encourage solar energy across the globe further.

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