WHITE PAPER
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Building a Resilient Energy Grid: The Impact of Community Solar Integration

Metropolitan ENERGY CENTER

Written by
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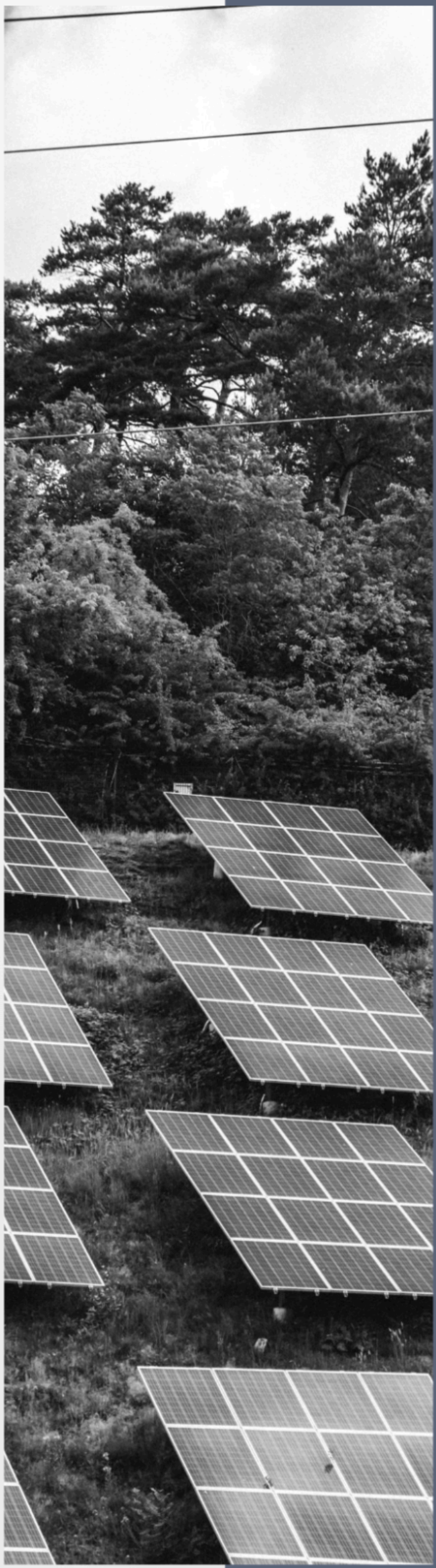

About Metropolitan Energy Center

The Metropolitan Energy Center (MEC) is a nonprofit organization based in Kansas City, Missouri, dedicated to promoting energy efficiency, environmental health, and economic vitality across the Kansas City region. Since 1983, MEC has worked to transform energy use in the building and transportation sectors, the two largest sources of greenhouse gas emissions, in order to pursue an environment with improved air quality. MEC works closely with residents, businesses, and municipalities in order to improve the health and wellbeing of everyone who inhabits the Kansas City region. From advocacy for clean fuels to promoting energy efficiency, MEC is committed to achieving cleaner, more sustainable practices across the region.

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Introduction

The vast network of interconnecting power lines, substations, and generating stations that powers our residences, workplaces, and industries is the electric grid, an impressive feat of engineering. It's a system that has been painstakingly created to precisely balance supply and demand in real time. But there's a significant issue facing our current energy grid: outdated infrastructure. Numerous components have lost reliability and become susceptible to failure. With climate change worsening, natural disasters have increased in frequency, but the aging grid is struggling and is left vulnerable to these increasingly extreme storms. Furthermore, the pressing need to cut greenhouse gas emissions necessitates large-scale integration of clean energy sources. However, the aging infrastructure makes it difficult for sources of renewable power to seamlessly join the grid. Regardless, integration of renewable sources is exactly what is needed to strengthen the energy grid and combat power outages. Because of its accessibility and positive impact on communities, community solar projects stand out as a route toward a more resilient energy grid.

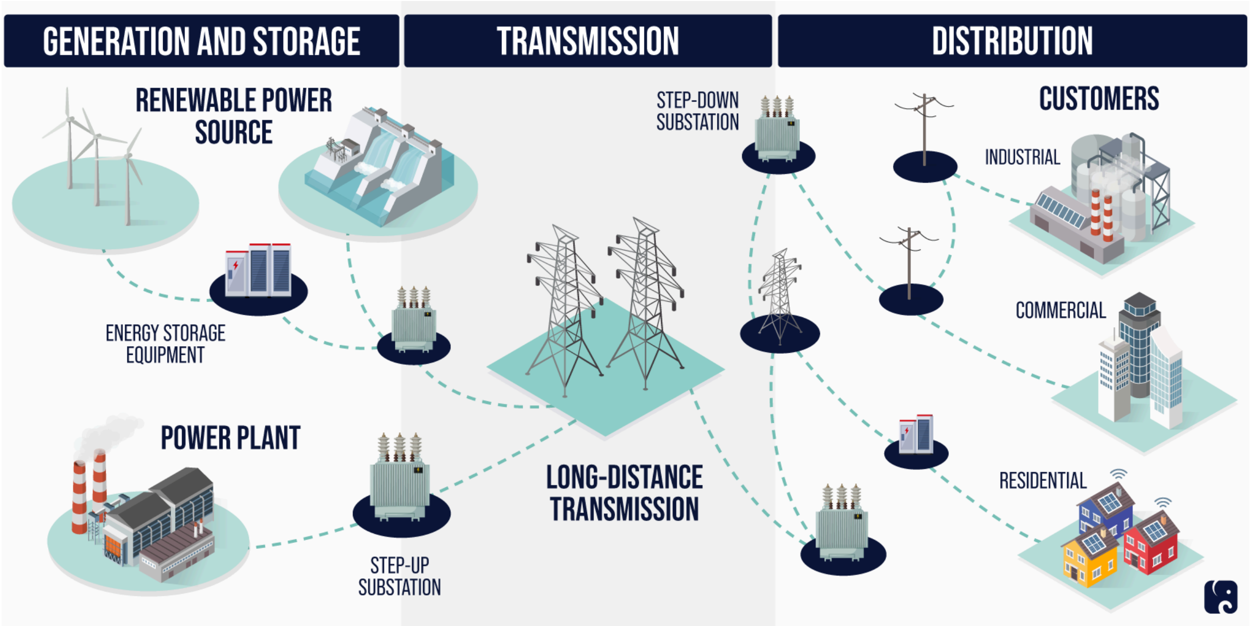
Grid resiliency refers to the energy grid's ability to withstand and quickly recover from disruptions, whether they are caused by natural disasters, technical failures, or cyberattacks. As a result of climate change, weather related power outages have been on the rise in the past decade. To reduce the negative impact of these outages, maintaining a resilient grid is of paramount importance. Large scale outages can have hugely detrimental impacts, particularly in the healthcare, communications and transportation industries. A resilient grid ensures a reliable supply of electricity, which is critical for the functioning of modern society. The integration of renewable projects into the energy grid represents a significant opportunity to enhance this resiliency. By decentralizing power generation, sources such as community solar can reduce the grid's vulnerability to disruptions and provide a more flexible energy infrastructure.

The purpose of this white paper is to provide an analysis of the current state of the energy grid and explore the role of renewable energy integration, particularly community solar, in improving the resiliency of the energy grid. As renewable energy sources become increasingly central to the power grid, community solar projects offer a unique approach to decentralizing power generation. This white paper will analyze the potential benefits, challenges, and practicality of incorporating community solar into the grid. The scope of the analysis will include: examination of the feasibility of renewable integration, referencing numerous case studies to determine the success of community solar in the past, and a consideration of policy and regulatory restrictions.

Current State of the National Energy Grid

The existing energy grid is a complex network which is designed to generate, transmit and distribute power, taking it from power plants to end consumers. This method is known as the three phase electric power and is commonly used for alternating current electric power transmission. As seen in Figure 1, the grid's infrastructure consists of many key components: generation facilities, transmission lines, substations, transformers, and distribution networks. Power plants are the initial points of electricity generation, and there is a vast array of power plant types. These include fossil fuel based facilities (coal and natural gas), nuclear plants, and renewable energy sources (hydroelectric, wind, solar). High voltage transmission lines then send this electricity over long distances, eventually arriving at substations, where the voltage is reduced to distribution levels using transformers. The power is then sent through another network of lower voltage transmission lines that deliver power directly to homes, businesses, and public buildings.[1] This intricate system attempts to ensure the efficient delivery of power across the entire country. However, the fundamental structure of the US energy grid remains flawed, and in a way, sets itself up for failure.

Figure 1. Diagram of The Energy Grid



Source: *Infrastructure Cybersecurity: The U.S. Electric Grid*. (2021, July 16). Senate Republican Policy Committee. Retrieved June 13, 2024, from https://www.rpc.senate.gov/policy-papers/infrastructure-cybersecurity-the-us-electric-grid

A Divided Grid

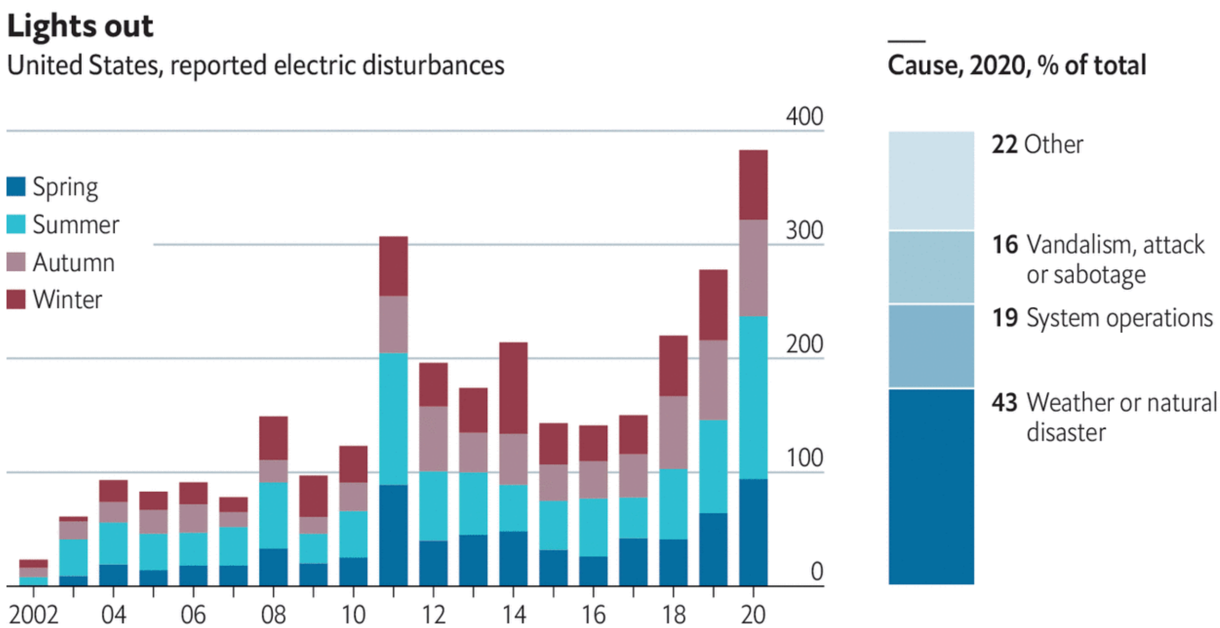
In the US, the grid is divided into three sections: the Eastern Interconnection, the Western Interconnection, and the Electric Reliability Council of Texas (ERCOT). This division has a great impact on the grid's interconnectedness and resilience. Each section operates independently, which poses great challenges in the transfer of electricity. Particularly in times of peak demand or in emergencies, the inefficiency of three separate grids is highlighted. While this segmentation may allow for easier localized control, it also means that issues within one interconnection are heavily magnified. With no way to receive significant support from other sections, a grid is left largely isolated when facing an issue. Although the grid's structure allows for efficient power distribution, it leaves far too much vulnerability to any outages or fluctuations in demand. The flexibility and robustness of the country's energy supply are sacrificed under the current system. So why doesn't the United States unite its three grids? For starters, the process would be long and extremely costly. However, once combined, there would be enormous financial benefits and the grid would be much more reliable.[2] The most influential reasons for the maintenance of divided grids are political. Politicians are attempting to protect the coal industry which would be disadvantaged by combining the grids.[3] If combined, the integration of renewable energy would be even easier as they could be better balanced across the country and the supply and demand curve could be easier managed.[3] However, the uniting of the grid seems unlikely for the foreseeable future, so other solutions to improve grid resiliency must be found.

Challenges Facing the Current Energy Grid

Furthermore, the energy grid faces numerous other challenges, primarily stemming from aging infrastructure and reduced flexibility. The US power grid, while strong relative to many developing countries, has great room for improvement. The average US customer loses power for 214 minutes a year.[4] It's only 70 minutes per year in the United Kingdom, 53 minutes in France, 29 minutes in the Netherlands, 6 minutes in Japan, and 2 minutes in Singapore. Since 2015, the US has experienced on average at least one grid related disaster each month that has caused at least 1 billion dollars in damages.[5] As Figure 2 shows, these outages are on an upward trend and will only continue to rise. Looking at the statistics, the US pales in comparison to many other countries in terms of energy reliability. In fact, the North American Electric Reliability Corporation (NERC), in their 2023 State of Reliability Report found that traditional fossil fuel generation was experiencing its highest level of unavailability and responding poorly to extreme weather events.[6] Looking at Winter Storm Elliot in December of 2022 as an example, fossil fuel sources are clearly to blame.[7] PJM, a grid operator in the region, found that 86 percent of its outages were due to coal and gas plants. It was also found that wind production remained high during the storm, and those plants remained strong in the face of the weather disaster.

Furthermore, the US grid lacks the amount of clean energy that many other countries have. Around 20% of US energy is clean, but many countries such as Paraguay, Ethiopia, Norway, and Switzerland are approaching the 100% mark.[8] The US efforts to convert to green energy are far behind in comparison. Looking at those other countries as examples, the US can see that a completely renewable grid can be more resilient.

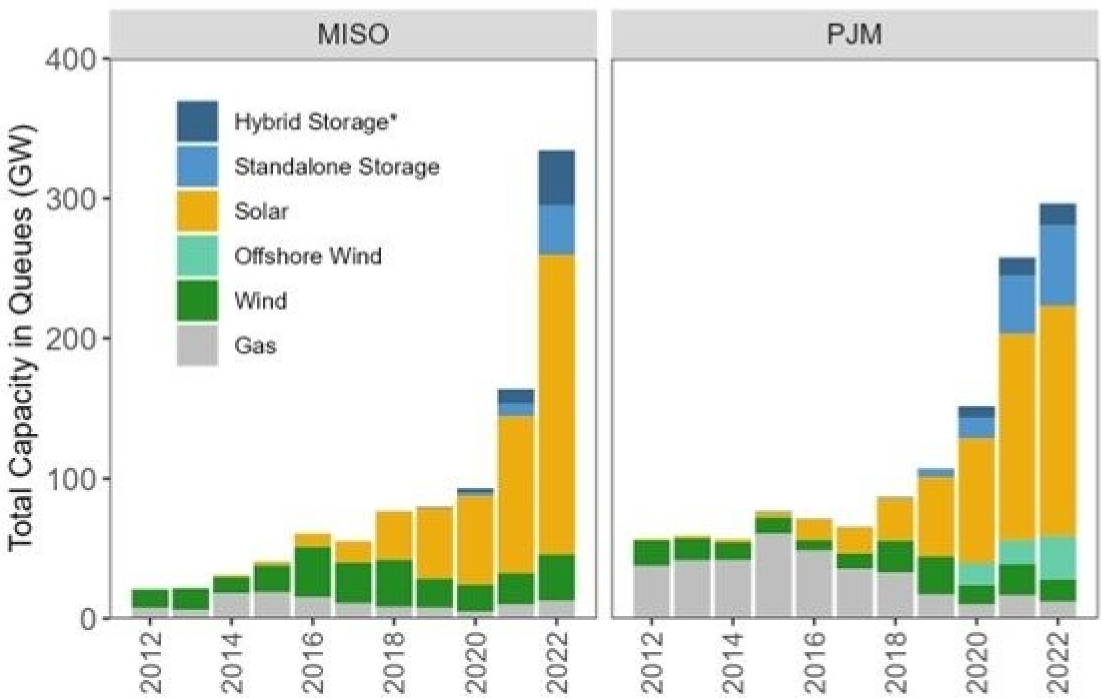
Figure 2. Reported electric disturbances from 2002 to 2020



Source: Power outages like the one in Texas are becoming more common in America. (2021, March 1). The Economist. Retrieved June 13, 2024, from https://www.economist.com/graphic-detail/2021/03/01/power-outages-like-the-one-in-texas-are-becoming-more-common-in-america

The age of the power grid also has to be taken into account. Most of the US electric grid was built in the 1960s and 1970s, and over 70% of the existing grid is more than 25 years old.[9] These aging systems lead to reliability issues, higher maintenance costs, and increased vulnerability to weather.[9] Most prominently, extreme weather events often result in major grid outages. In 5 of the past 11 years, parts of the grid have been hit by blackouts or shut-offs due to cold weather, and power outages have doubled in the past 20 years.[10] As extreme weather events increase in frequency as a result of climate change, and the grid continues to age, these problems will only worsen. Looking at Figure 3, two of the largest Regional Transmission Organizations in the United States, MISO and PJM, are experiencing building levels of energy capacity in Queues. Due to inefficient interconnection processes, large portions of energy get stuck in queues, waiting to be approved. These queues limit the grid and prevent massive amounts of energy capacity from being utilized. The vast majority of energy in these queues is renewables, because these are the new projects which are waiting to be approved. This inefficiency in the grid makes it cumbersome for renewable projects to get connected to the grid. Furthermore, the aging power plants in the grid make it inefficient and costly to constantly ramp energy production up and down to account for differences in demand.[11] These older plants hamper the ability to integrate renewable energy into the grid. The grid was built to operate on centralized, large scale plants, so the integration of distributed renewable sources proves to be challenging. However, this integration is exactly what the grid needs to be able to effectively respond to outages and safeguard the energy of communities.

Figure 3. Capacity of energy in queues from 2012 to 2022 under the operators MISO and PJM



Source: Sanders, J. (2024, March 21). The Increase in Power Demands and an Aging Grid.
Freedom Energy Logistics. Retrieved June 13, 2024, from https://felpower.com/the-increase-in-power-demands-and-an-aging-grid/

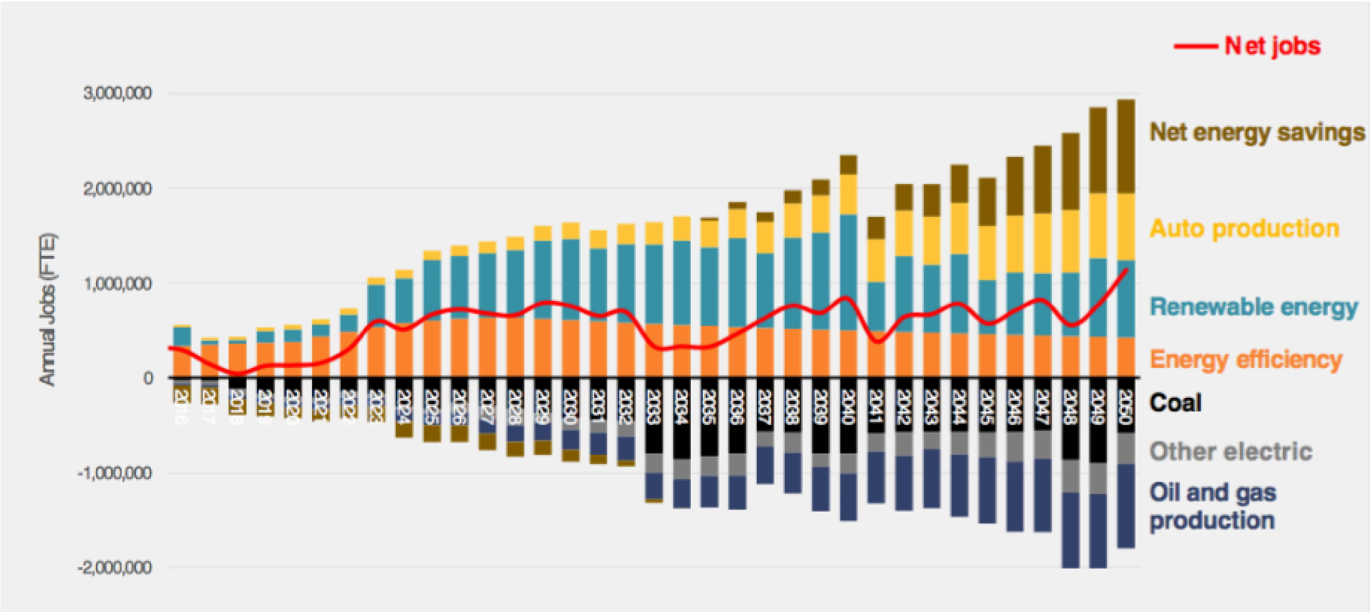
Renewable Energy Integration

Benefits of Renewable Energy

Although the benefits of renewable energy may seem apparent, it's essential to highlight their specific impacts in order to fully understand their role in the changing energy grid. These impacts can be broken up into Environmental benefits, Economic benefits, and Technological advancements. For starters, the driving force behind the push for renewables is their substantial influence on the environment. Renewable energy sources, such as solar power, wind power, hydropower, and geothermal produce little to no greenhouse gas emissions in their generation. These forms of generation are a stark contrast to traditional fossil fuels, which release carbon dioxide and other pollutants in large quantities, contributing to global warming. Currently, electricity generation produces one third of the US carbon emissions.[12] By expanding renewable power plants on a large scale, the energy sector's carbon footprint can be drastically reduced, mitigating global warming and reducing air pollution. On top of eliminating emissions, renewable plants often have smaller physical footprints, which contributes to the preservation of natural habitats and biodiversity.

Secondly, the economic benefits of renewable energy will be profound in the long term. We have already seen a steady decrease in the cost of renewable energy, making it increasingly competitive with traditional energy sources.[13] As industries surrounding renewable production continue to expand, numerous job opportunities in manufacturing, installation, maintenance, and research sectors will be created. As renewable energy plants replace traditional fossil fuel plants, some jobs will be destroyed while more are created. Figure 4 shows that the renewable energy sector will create far more jobs than it destroys by replacing fossil fuels. As those fossil fuel plants are phased out, the economy will grow as more jobs are created from renewables. Additionally, the development of decentralized energy projects, such as community solar, can greatly stimulate local economies. Renewable sources also have greater price stability, as they are not subject to the volatile fluctuations in price that are characteristic of fossil fuels. The multifaceted economic benefits of renewables will work together to produce a substantially stronger economy over time. In fact, projections show that doubling the share of renewables in the global energy mix will increase global GDP by 1.1% by 2030.[14] Countries around the world will experience greater energy security and independence because of their reduced reliance on imported fuels.

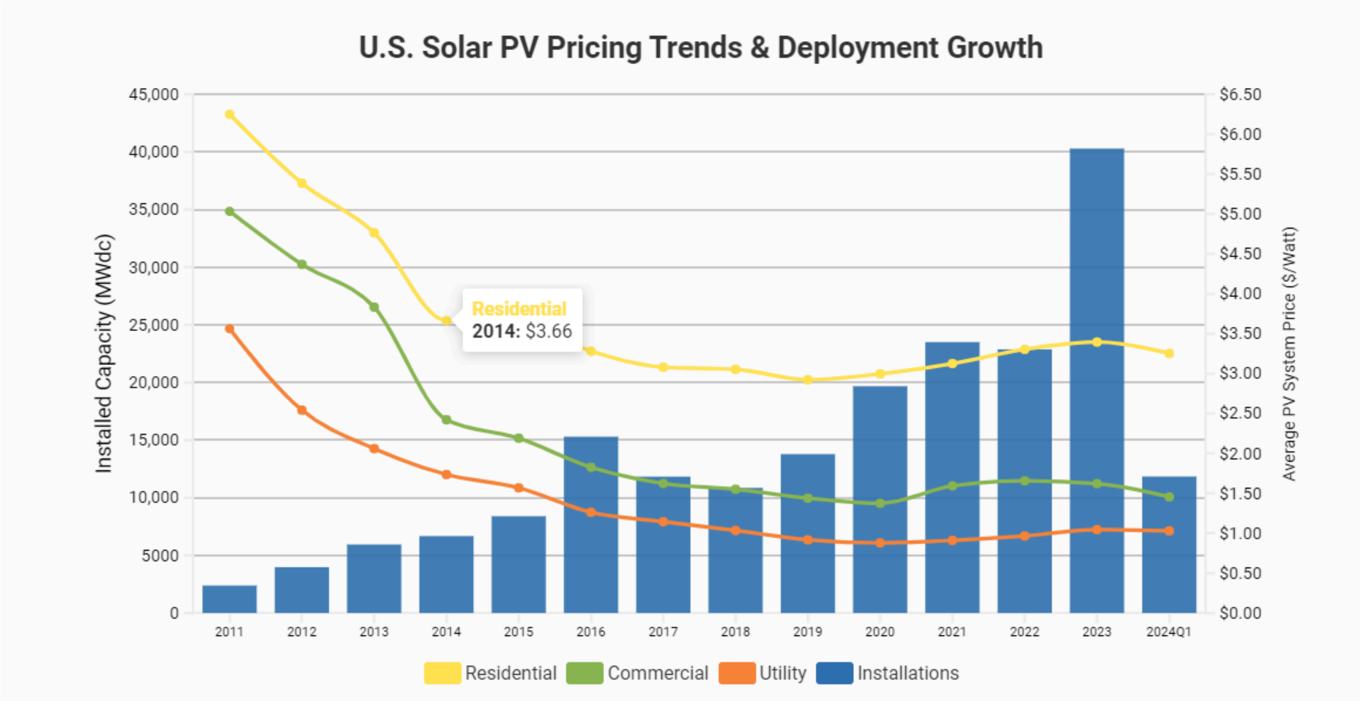
Figure 4. Annual job creation results and future projections in various energy sectors



Source: Roberts, D. (2015, October 21). *Clean energy creates some jobs and destroys others. Here's what that tells us about politics.* Vox. Retrieved June 13, 2024, from https://www.vox.com/2015/10/21/9586214/clean-energy-jobs-politics

Finally, and arguably most importantly, as dedication toward renewables increases, innovation in the energy sector spurs significant technological advancements. Countless examples of technology that are being utilized today serve as testaments to this innovation, and newer technologies will only continue to be developed. Breakthroughs in photovoltaic cell technology, wind turbine design, energy storage solutions, and smart grid infrastructure serve as examples toward the rapid advancement prevalent in the renewable industry. These innovations will continue to not only improve the cost and efficiency of renewable sources, but will also enhance their ability to be integrated into the larger grid. In recent years, this trend of technological developments has already become apparent as prices drop steadily for renewables. Figure 5 shows the decrease in the price of solar panels as its installed capacity continues to rise. This trend will continue in all renewable sources and prices will become more and more affordable due to innovation. As technology continues to evolve, both the economic and environmental benefits discussed will only compound into the future.

Figure 5. Price change in various type of solar panels and growth in installations

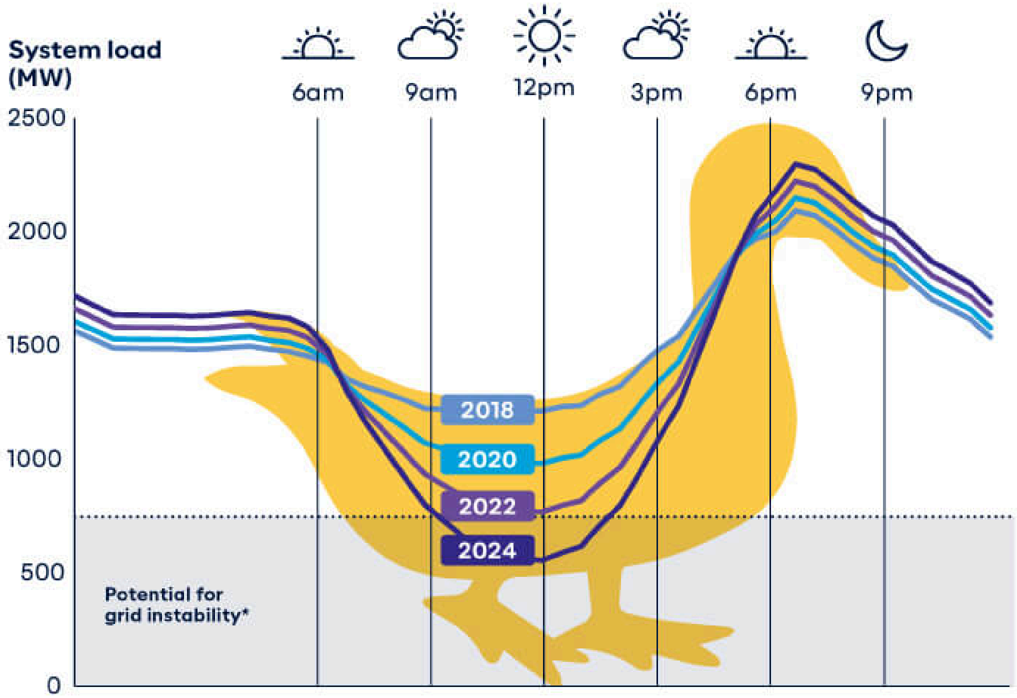


Source: Solar Industry Research Data | SEIA. (n.d.). Solar Energy Industries Association. Retrieved June 13, 2024, from https://www.seia.org/solar-industry-research-data

Challenges of Renewable Energy Integration

One of the primary challenges of integrating renewable energy is adjusting to the supply and demand of the grid. Sources such as solar and wind power are inherently variable and depend on weather conditions, time of day, and time of year. For instance, solar energy meets a challenge known as the "duck curve", depicted in Figure 6.[15] Solar production is the highest in the middle of the day and lowest in the evening and morning, which happen to be the opposite times for when energy is needed the most. This results in a curve in energy demand that is shaped like a duck and a wastage of resources because of unideal production times. Furthermore, the intermittency and unpredictability of solar and wind play a role. During January and February, wind and solar production is at an all time low. Because of this, during these months, coal and gas production must be ramped up in order to meet demand. However, these periods of low production happen at different times across the country, so widespread interconnection is essential in limiting the need for non renewable resources. However, as mentioned before, the US grid is fragmented and this interconnection is next to impossible. With vast fluctuations in the power output of solar and wind, energy storage solutions and complementary power sources must be developed to ensure the supply of energy can always meet the demand.

Figure 6. Graph of deepening duck curve since 2018



Source: *Solar Duck Curve Explained: What it Means in Western Australia*. (n.d.). Synergy. Retrieved June 13, 2024, from https://www.synergy.net.au/Blog/2021/10/Everything-you-need-to-know-about-the-Duck-Curve

Because of the lack of the modern grid's flexibility, significant investment is required to modernize grid infrastructure in order to effectively support renewables. For starters, solar and power plants will need to be coupled with storage systems in order to smooth out the fluctuations in production. The aforementioned duck curve could be easily smoothed out by saving the energy produced during peak production times and using it during the time of peak demand. As the grid becomes increasingly reliant on renewable sources, batteries are essential to ensure the efficiency of the grid. Otherwise, large amounts of power will be wasted. Simple lithium ion batteries found in cars could solve this problem.[16] However, these batteries come with challenges of their own, being extremely expensive for large scale power plants. Furthermore, current infrastructure lacks sufficient transmission lines to support the further development of renewable sources such as wind farms.[17] These plants have to be located in rural, remote areas, and new lines will need to be built to reach these areas. Like the batteries, this is an extremely expensive endeavor, which will take 10-15 years to complete. However, it is necessary in order to take full advantage of renewable sources.

Impact on Grid Resiliency

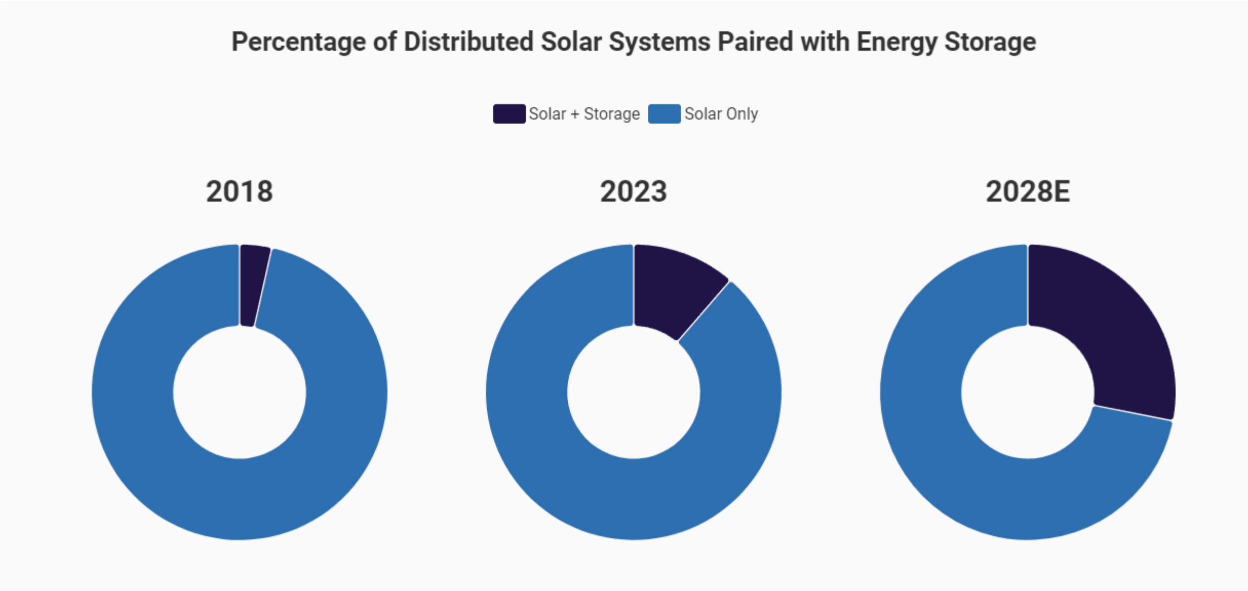
Enhancing Local Grid Stability

Regardless of the numerous challenges facing the integration of renewable energy, it is the key to building a resilient electricity grid. In the wake of failing fossil fuel-fired plants, the United States must shift away from conventional generation in order to maintain reliability. A grid run largely on renewable sources will have both enhanced local grid stability and grid flexibility across the nation. Renewable energy sources such as solar and wind have a high potential to be used as decentralized forms of power. Operating essentially as microgrids, these independent sources of power would allow communities to protect themselves against natural disasters or any other disruptions to the main grid. As these sources would be distributed across various locations, the risk of widespread outage caused by a single point of failure would be greatly reduced. This application is particularly useful for public buildings or businesses such as hospitals. If a city is experiencing a major power outage, the impacts on a hospital are life threatening. Vital equipment such as ventilators, incubators, and dialysis machines need electricity to function, and patients are relying on them to survive.[18] However, if the hospital was connected to a microgrid run by renewable energy, the patients within would be safeguarded from any potential blackouts.

Supporting Grid Flexibility

Not only does renewable energy improve the stability of local communities, but the flexibility of the grid as a whole would also be augmented. Under old infrastructure and power plants, the modern grid lacks the flexibility needed to sharply scale its output up or down. However, the inherent modularity of renewable energy sources allow their output to be rapidly scaled in order to respond to fluctuations in supply and demand. This increased flexibility is crucial to accommodate for the variable nature of wind and solar. Grid operators already have countless solutions to ensure that wind and solar can contribute to improved grid reliability regardless of their intermittent nature. First, by utilizing a diverse array of renewable sources with sufficient transmission and energy storage capacity, the grid can be balanced enough to ensure reliability.[19] There have already been some pushes toward this goal. The Biden administration's agenda, Investing in America, has made investments toward developing energy storage solutions and expanding transmission infrastructure. Under the usage of storage systems, the intermittency issues of wind and solar are completely solved. Looking at Figure 7, it's apparent that storage systems will continue to be used more heavily. Projections for 2028 show that a much larger percentage of solar panels will be accompanied by storage, mitigating the natural fluctuations in solar production. Secondly, other renewable energy sources such as geothermal, hydropower, and biomass do not have the same intermittency issues.[19] These plants could help overcome the variation in output from wind and solar and ensure that supply is always met throughout all seasons and times of day. This goal of balancing supply and demand is known as resource adequacy.[20]

Figure 7. Rise in energy storage used with solar panels since 2018 and projections for the future



Source: Solar Industry Research Data | SEIA. (n.d.). Solar Energy Industries Association. Retrieved June 13, 2024, from https://www.seia.org/solar-industry-research-data

Resource Adequacy

Despite worries that higher percentages of renewable sources will sacrifice the grid's ability to meet demand, numerous studies have shown that a decarbonized grid can maintain resource adequacy. A study done by University of California, Berkeley found that a 90% clean grid is achievable by 2035.[21] The projections showed that energy demand could be met at all times, while retiring all coal plants and only maintaining half of current existing fossil fuel capacity. The National Renewable Energy Laboratory found that an 80% clean energy grid could maintain resource adequacy.[22] Even with high usage of wind and solar energy, the grid would be able to be balanced. A meta-analysis from Energy Innovation looked at 11 studies by researchers who modeled an 80% clean energy grid.[23] They found that in all studies, the grid was able to match supply and demand. Five of these studies ran projections with extreme weather conditions, and the clean energy grid stayed reliable throughout. Furthermore, researchers from LUT university published a study proving that 100% renewable energy around the world is economically and logistically possible by 2050.[24] Numerous other studies from leading researchers have backed these results in similar studies.[24] The evidence shows us that a 100% renewable grid is undoubtedly possible and that grid resiliency will only increase with this shift. Looking to other countries as examples further proves that resource adequacy will be upheld by renewables. Numerous nations such as Iceland, Paraguay, Norway, and many more are run nearly 100% by renewable energy.[25] These countries boast secure, reliable grids because of their renewable composition.[26]

Ancillary Grid Services

Resource adequacy, although essential to the grid, is just one part of grid reliability. Ancillary grid services, which ensure reliability and support the transmission of power from plants to consumers, must also be provided effectively.[27] Some of these services include load regulation, voltage support, frequency response, and ramping capabilities. These are all essential in maintaining a reliable energy system and recovering from any power disruptions. Renewable sources are particularly strong at providing these ancillary services and are often even more effective than conventional fossil fuel generators. NREL, First Solar, and California ISO conducted a trial of tests on a solar power plant in order to examine the effectiveness of its ancillary services.[28] The study found that the plant was well-equipped to offer a wide range of ancillary services. In all their tests, the solar plant performed similar to or better than a conventional fossil fuel plant. A similar study by the NREL was conducted on a wind farm and similar results were found in which the wind farm performed well up to standards.[29] The vast impact of renewable sources on grid resiliency cannot be understated. Considering the fragile state of the modern grid, action must be taken to prevent further decay and strengthen the grid. Ramping up renewable energy sources is the ideal solution to both conserve the environment and build grid reliability and resiliency.

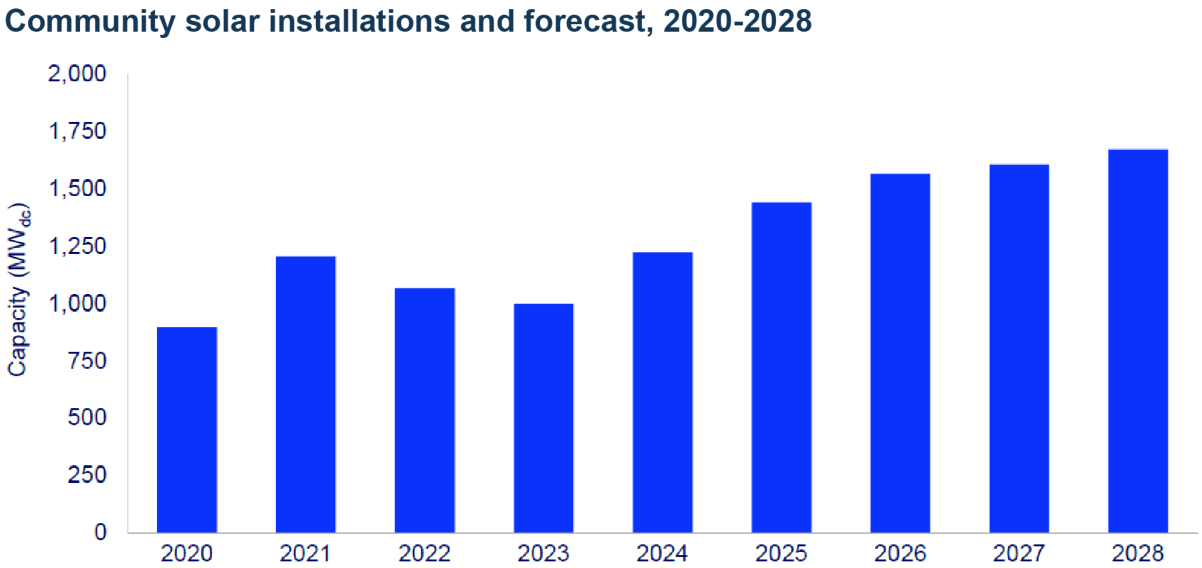
Community Solar: A Key Component

Definition and Overview of Community Solar

Community solar projects play a foundational role in increasing the resilience of the nation’s electric grid. They present a collaborative approach to solar energy, where a community takes ownership in a solar project that is used to power their homes or businesses. Rather than a community relying on one energy source to power their region, community solar ensures that a redundant energy source is provided. This can act as a backup energy source to provide power in blackouts or times of high demand. If coupled with a battery storage system, these projects become even more effective. The revenue and power output from community solar will increase greatly by using batteries to save power until demand is higher relative to supply.[30] Thus, extra funds can be directed internally into the project in order to either expand or further improve efficiency. These storage systems contribute to the energy grids within a community being further strengthened.

Community solar differs from individual solar systems in the fact that they are typically located off-site rather than on the homes of businesses of owners. Furthermore, they often involve larger scale systems that are maintained by professional operators rather than the individual owner, ensuring optimal performance and longevity. Opposed to individual solar projects, community solar can be placed in an optimal location in order to ensure maximum efficiency. Community solar makes accessing clean energy feasible for a much greater percentage of the population. In this way, these projects are able to serve multiple users who may not have the ability to install their own solar panels. Figure 8 shows the steady increase in community solar since 2020 and projects its growth into the future. Each year from now, the capacity of community solar is expected to grow, becoming a more common renewable source. Being more accessible, community solar is an excellent avenue which offers educational opportunities to community members about solar panels and their potential.

Figure 8. Projections for community solar capacity growth into 2028



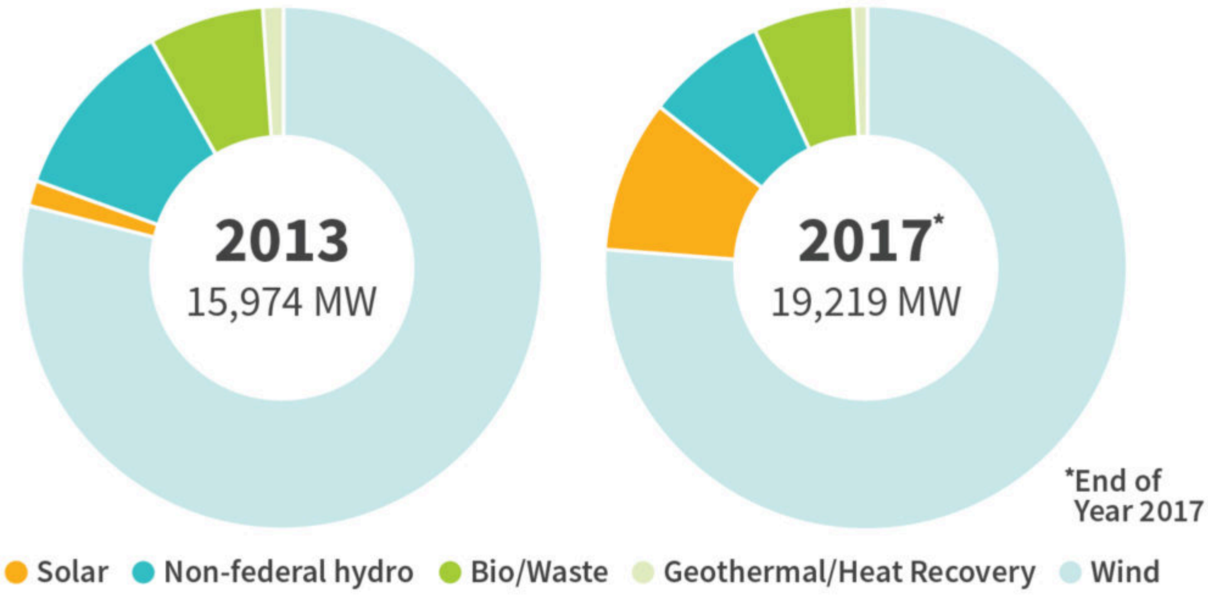
Source: Solar Market Insight Report 2023 Q3 | SEIA. (2023, September 7). Solar Energy Industries Association. Retrieved June 13, 2024, from https://www.seia.org/research-resources/solar-market-insight-report-2023-q3

There are many different methods of ownership for a community solar project.[30] In some cases ownership means that community members serve as leaders and have authority to make decisions on the project, but in other cases, members simply subscribe to the solar project. In a member owned cooperative, people own shares of the solar project as if it's a business. They are all shareholders in the project and therefore all have authority over its decisions. In the opposing model, the regional utility company or a third party developer owns the solar project and provides the community with benefits in exchange for their support of the project. Community members can buy into a subscription in exchange for credits on the generated electricity. Both these strategies, although differing, are excellent ways to involve communities in the push for renewable energy and bring countless benefits to the reliability of energy within the community.

Advantages of Community Solar

Community solar offers unique advantages over other forms of distributed energy and large scale renewable power plants, particularly in enhancing grid resiliency. Large power plants, such as solar or wind farms, often require significant infrastructure investments and can be vulnerable to disruptions in a single region. In contrast, community solar projects are typically distributed across various regions, ensuring multiple points of production. The dispersion allows the grid to adapt to localized disruptions while maintaining stability across the broader grid. The infrastructure investment for a new large scale power plant often includes the construction of transmission lines and substations, but community solar projects can be connected to the local grid directly. As seen in Figure 9, these benefits over other renewables have led to an increase in the percentage of solar compared to other renewables from 2013 to 2017. Solar is the fastest growing renewable in the United States.

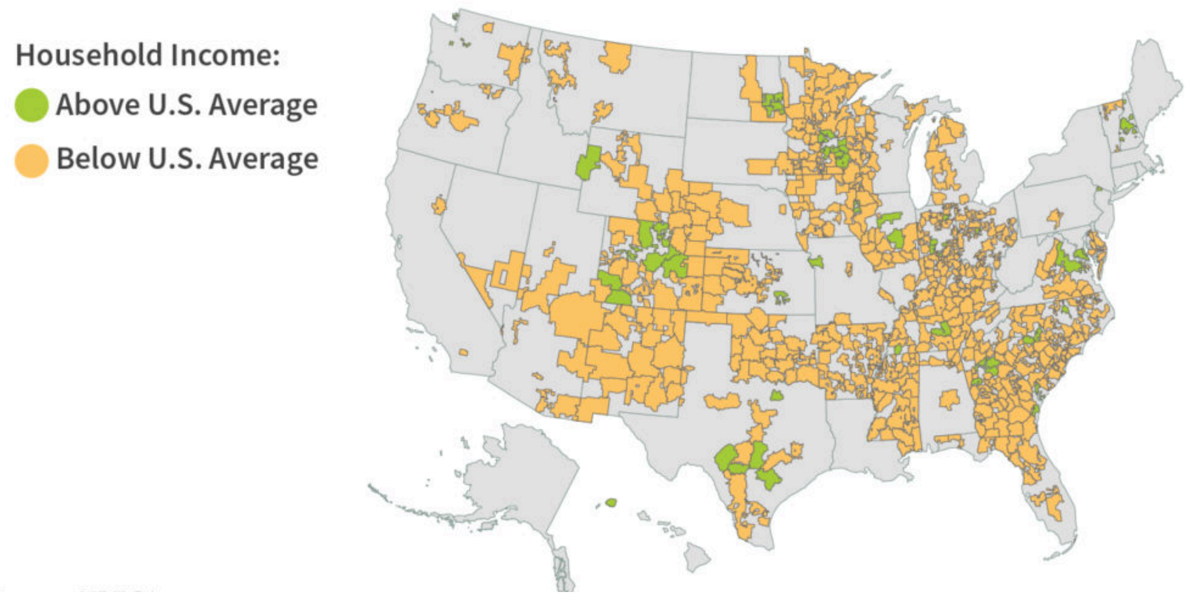
Figure 9. Change in makeup of renewable sector from 2013 to 2017



Source: Rocha, V. A. (2018, July 17). The Story of Co-op Solar in Nine Graphics. National Rural Electric Cooperative Association. Retrieved June 13, 2024, from https://www.electric.coop/the-story-of-co-op-solar-in-nine-graphics

Most importantly, community solar empowers local communities to get involved in the push for renewables in ways that large scale plants fail to do. The ease of accessibility of community solar is where it truly shines. The majority of the United States would be unable to invest in rooftop solar panels for their house or place of business because of the financial limitation. However, community solar is extremely affordable and allows all to participate in the push for clean energy. Figure 10 showcases this accessibility with a map of community solar across the country. The colors show that a large portion of households involved in community solar are below the US average household income. This means that communities that wouldn't ordinarily invest in the environment, now have the access to do so. This localized ownership encourages engagement among the community in the support for renewable energy initiatives. Going past the environmental incentives, community solar also brings many economic benefits to the region.[30] In addition to household energy savings, these projects often build local job creation which stimulates the local economy. The activism that community solar brings combined with its positive economic impact makes it a truly unique form of distributed energy.

Figure 10. Map of household income of community solar participants



Source: Rocha, V. A. (2018, July 17). The Story of Co-op Solar in Nine Graphics. National Rural Electric Cooperative Association. Retrieved June 13, 2024, from https://www.electric.coop/the-story-of-co-op-solar-in-nine-graphics

Case Studies

Although there is a vast expanse of study projections proving the benefits of renewable energy integration on the grid's resiliency, the benefits aren't just in theory. There have been countless cases of community solar projects that have been implemented in communities around the globe. These projects act as examples to the specific benefits that community solar can bring. The numerous successful projects show the potential for further community solar moving into the future. These are just a few of countless community solar case studies:

- Owned by two tribes in Shungnak and Kobuk, Alaska, the Shungnak-Kobuk Community Solar Independent Power Producer (IPP) project is a solar-battery microgrid that produces solar electricity at a lower cost than diesel generated power.[31] This community has been historically reliant on diesel to generate electricity, and these solar panels aim to lower the cost of electricity in the region. During the daylight season, the diesel generators in the region can turn off for

8-10 hours a day, while the solar panels, paired with their battery storage, completely take over. This project is first of its kind in Alaska, and is a significant step forward in the futures of the residents and tribes in Alaska.

- The Oregon Shakespeare Festival Community Solar Project is an example of a subscription based project.[32] Although already owned by various Oregan residents, anyone living in the community has the opportunity to get involved. It includes roof mounted panels in Talent, Oregon and offers bill credits to its subscribers. In order to allow low income subscribers with the same opportunities, the project developers leveraged grant funding in order to lower costs of subscription. In addition to giving out credits, the project serves as an emergency backup to the Festival building during performances.

- Grand Valley Power is a utility company in Colorado who developed two community solar projects.[33] This is another subscription based community solar project, but it's owned by a utility company rather than community members. Individuals had the option to either pay upfront or over time and they each received a bill credit of 4 dollars a month from the system output.

- The Harvard Solar Garden is located in Harvard, Massachusetts and is a product of the Solarize Mass program from 2011.[34] Many residents were not able to participate in the Solarize Mass program because of site limitations on their houses. This challenge sparked the idea of a shared ownership community solar project. Solar Design Associates, a firm from Massachusetts, designed and engineered the project. Over 100 communities have access to this subscription and can benefit from net metering once subscribed.[35]

- The Fremont Community Solar Program was initiated by the Fremont Department of Utilities.[36] This was a relatively large-scale project that reduced the city's dependence on fossil fuel plants. Residents had two different options to get involved. A direct purchase of panels, which allowed the purchaser to take advantage of the federal tax credit, or the purchasing of shares to help offset their monthly power usage. This particular project had a strong impact because of its education efforts that accompanied its development. A survey by the utility department revealed that 35% of residents did not understand community solar. The project team was able to make strides in educating residents on the impact of their involvement in the solar project.

- Looking at specific examples can show us the localized impacts of community solar, but by examining Australia's widespread implementation of community solar, the nationwide impacts are outlined. Australia has the highest per capita usage of solar panels and over a third of their households have solar.[37] They have thousands of community solar projects and the largest share of their solar installations came from distributed sources.[38] The government has invested 100 million dollars into community solar banks which will contribute to lower electricity costs for 25,000 households.[39] Australia has experienced reduced pressure on their grid since their increase in solar.[40] The resiliency benefits from community solar have been key in averting grid failures from extreme weather events.[41] The US can mirror Australia's effective strategy by investing in community solar systems and incentivizing residents to buy in.

Policy and Regulatory Considerations

Current Policies and Regulations

As a transition to renewable energy continues to be stressed, more and more policies exist to support sustainability and clean electricity. For example, the federal Investment Tax Credit (ITC) has been a substantial incentive, offering a 30% tax credit on solar panel installations.[42] State level policies, such as net metering and renewable portfolio standards (RPS), often further promote renewable sources by mandating that a specific percentage of electricity sold by utilities come from renewable sources.[43] Currently 44 states have net metering policies.[43] A few states have implemented Interconnection policies which help simplify the application process for community solar and prevent extended wait times.[43]

However, policy challenges still persist and can often hinder the development of community solar projects. The variability in state regulations creates inconsistencies across borders and can greatly decrease the efficiency of solar systems. Delays and additional costs are often caused by complex interconnection processes.[44] While many states have strong net metering policies, other states are lacking in them and the viability of solar projects in these states is often limited. Furthermore, the absence of a standardized procedure for permitting processes makes it lengthy and cumbersome to get approval.[45] Different jurisdictions have various requirements and this can lead to delays and increased costs due to the absence of a streamlined process. While many of the difficulties are due to government decisions, the utility companies also play a role. Utilities often resist community solar projects within their area due to concerns about revenue loss.[46] In many cases, these companies have significant market power and can influence regulatory decisions in order to protect their interests. The growth of consumer owned electricity generation often poses a financial loss to these utility companies and they are incentivized to oppose it. The current policies are a step in the right direction, but significantly more action is necessary to support the potential for large scale change.

Recommendations for Policy Makers

Current policies could be improved to support the ongoing success and future development of community solar. Firstly, policies should be passed to encourage community solar adoption. States could implement or strengthen renewable portfolio standards with targets specifically for community solar. This could ensure that a portion of energy generation in each region comes from community solar. Net metering policies could be standardized across states and improved to guarantee that subscribers receive fair compensation for the energy that they contribute to the grid. Next, policies that incentivize infrastructure improvements should be passed. Encouraging utilities to upgrade grid infrastructure could allow community solar to connect to the grid with greater efficiency. These incentives could also promote utilities to invest in storage systems that have a strong impact on a grid's reliability. Finally, the approval process for community solar projects must be streamlined. A standardized application across the nation would greatly reduce the time and resources that need to go into getting a project approved. Establishing clear interconnection policies and standards across states would minimize delays and costs with connecting community solar to the grid. By taking into account these proposed policies and by continuing to improve on and strengthen current ones, community solar will be able to flourish in all states.

Conclusion and Key Takeaways

The integration of community solar into the broader energy grid presents a compelling opportunity to enhance grid resiliency in a uniquely advantageous manner. There is an urgent need to modernize energy infrastructure, particularly in the face of increasing weather disasters from climate change and aging infrastructure. To meet these challenges the current energy grid must undergo significant modernization. The failing fossil fuel plants must begin to be fazed out to prevent further failures.

Renewable energy stands out as a necessary solution. The environmental and economic benefits cannot be understated and coupled with the rapid innovation in the field, the advantages of renewables will only continue to grow. However, the challenges associated with renewable energy integration into the fragile grid must be addressed. The intermittency, infrastructure needs, and regulatory barriers must be addressed in order to fully utilize the power of community solar.

The integration of distributed energy sources such as community solar is vital in hurdling these challenges. These energy sources are inherently flexible and able to quickly ramp their output up and down. By using a storage system and focusing on community solar projects, the intermittency and infrastructure issues are solved. Furthermore, solar projects can be coupled with more stable renewable sources such as geothermal and hydropower to maintain resource adequacy at all times.

Community solar offers unique advantages that make it stand out among other renewable sources. The localized approach makes this a much more accessible avenue for supporting renewables. Traditional rooftop panels can be very costly and the affordable nature of community solar makes it easy to buy in. Furthermore, the community benefits from a boost in economy from the jobs that community solar creates and from the panel's revenue. Education and involvement about the environment is spurred among individuals who couldn't normally take action. And finally, community solar strengthens the local grid and provides a backup to the community in times of emergency.

To support widespread adoption of community solar and other renewable sources, it is crucial for policies to be continually improved on and new policies to be created. Recommendations include incentivising infrastructure upgrades, streamlining application processes, and encouraging community solar adoption. As we transition to a renewable grid, policies must constantly adapt to support the changing grid.

Here are three key takeaways for policymakers, utility companies, consumers, and regulators:

- The current state of the energy grid is undoubtedly far from ideal. Facing fundamental issues in the divided energy grids and infrastructure problems across the country, the grid's performance is continually dropping. However, there is a solution to reinstate reliability and resiliency in the grid: Renewable Energy
- Although there are many worries that resource adequacy will be difficult to maintain by a fully renewable grid, the evidence shows that it can be done. Taking into account the rapidly developing technologies in the industry, by the time the grid is reaching the 80% mark, resource adequacy will be fully supported. Numerous studies support this fact with their projections and prove that supply and demand can be balanced effectively by renewables.
- Community solar is an ideal avenue to pursue grid resiliency because of its ease of accessibility. Because of its ability to be spread out in various locations, community solar has a particularly strong impact on overall grid resiliency. Considering its strong benefits to a community's economy, there really is no downside to community solar projects.

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