**Microgrids: Thinking Smaller**

Sabrina Nguyen, san86@pitt.edu, Mahboobin 4:00, Jackson Morton, jdm190@pitt.edu, Vidic 2:00

**Abstract** – The power grids that are currently installed in the United States were not built to handle the variable output produced by wind and solar energy. They were not structured to meet the demand of technological advances that are currently being developed and they must be managed closely by operators. To overcome these flaws, engineers have begun to expand their research into microgrids. They are small electric grids that contain a power generator, can distribute energy to attached loads, and are constructed so that they can function independently in case of an emergency. They are designed to be attached to the main power grid and channel energy from it, but if something damages the larger grid, the connection can be severed and the microgrid can provide its own energy to the attached loads. The development of microgrids provides an opportunity to produce higher quality electricity that is more reliable and environmentally friendly that can be implemented in various places like military bases, hospitals, and research facilities. The Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) is an example of how microgrids are implemented in the United States.

**Key Words** – Controllable Generation, Control Systems, Microgrids, Noncontrollable Generation, Power Grids, Self-Sustaining

**Introduction**

The world is becoming more and more dependent on electricity and as a result it needs an efficient power grid. With the world constantly evolving, the infrastructure of the power grid cannot keep up with the demand. Microgrids are electrical systems that can separate from the main grid to become an “island” and operate without relying on other electrical distribution systems. The importance of a microgrid lies within its ability to be self-sufficient, and generate enough power for whatever building or machinery is attached. Many people believe they would die without the use of energy which is just not true, however, there are facilities that depend on electricity for situations when lives are at stake. Sustainability is also a hot topic when it comes to energy due to our limited supply of resources. The development of microgrids is done with environmental, economic, and social sustainability in mind. Microgrids provide a solution in closing the gap of wasted energy and being more resourceful.

**The Current Power Grid**

The power grid currently stretching across the United States is slightly mismatched because it was built up over the years as needed while developments were still being made in the fields of power generation, power storage, and power transfer. This is part of the reason the grid is split into three main interconnections, grids on a regional scale that operate at a synchronized frequency and are electrically tied together [1]. The largest, the Eastern Interconnection, spans the east coast of the United States and stretches to Nebraska. The second largest, the Western Interconnection, stretches from the west coast to Colorado. The third and smallest Interconnection covers Texas. The main reason Texas has its own grid is because they wanted to remain free from federal oversight and regulations [2]. The Eastern and Western Interconnections also stretch up into the southern half of Canada tying the United States’ and Canada’s power systems together as shown in Figure 1.

**Figure 1** [1]

Map of the three interconnections in the United States

The grid that has grown across the United States over the past century was first introduced and promoted by Nikola Tesla and George Westinghouse. They advocated for the use of alternating current system, which allows electricity to be transformed to a higher or lower voltage for transportation [3]. This system quickly became popular and spread across the United States as cities and towns introduced electrical power.
Eventually these small, separate grids were connected to form the three interconnections we have today. These three interconnections, along with most others around the world, are comprised of four major components shown in Figure 2: individual generators, transmission lines, distributors, and loads (electricity consumers).

![Diagram of a simplified power grid.](image)

**FIGURE 2 [3]**
Diagram of a simplified power grid.

Individual generators, of which the number per grid varies from grid to grid, provide all the electricity that a grid will need. They generate electricity in a variety of ways but can be split into two broad groups, controllable and noncontrollable generation. Generators also vary greatly in their ability to be turned on or off quickly. For example, coal and nuclear plants are very inflexible taking a long time to turn on or off while natural-gas fired plants are very flexible and are often used to meet peaks in demands [3]. All generators, regardless of type, must be closely monitored and managed at all times to ensure that they do not produce too much or too little electricity.

Transmission lines are the lines that carry high voltage electricity over long distances and connect generators with loads. Transformers are used to convert low voltage electricity produced by generators to a much higher voltage for transmission in the transmission lines. For electricity to be transferred large distances without too much being lost, the voltage needs to be ramped up much higher than anything most people use in their day-to-day lives, because voltage decreases over distance. Longer wires have more resistance which reduces voltage. These lines are highly interconnected for redundancy and to try to prevent blackouts if one line goes down but they can still fail [3]. Once the electricity reaches the general area of the loads, another transformer converts it back to a lower voltage that can be used in homes and businesses.

After this transformation, the distribution network comes into play. This network is the system of wires that connects the transformers and the loads. Operators must closely monitor it to ensure that the proper amount of energy is always going to the right places [3].

Lastly, the electricity is delivered to the loads for consumer use. This is what allows people to use electricity in their everyday lives. Consumer demand for electricity varies by hour, day, and season, which greatly complicates the grid because operators must be able to meet the current demand no matter what it is. If operators do not keep electricity supply and demand balanced then they can provide too much which overloads the grid causing parts to automatically shut off, or they can provide to little which causes brownouts.

**Pitfalls of The Power Grid**

While our grid is currently meeting our demands, it is not perfect. It can easily fail when generation rises too far above or falls too far below demand [4]. Therefore, the spike use of solar and wind generation while good for the environment is hurting the grid. Both of these forms of generation are variable and as a result when they begin to produce less energy, when the sun stops shining or the wind stops blowing, other forms of generation are required to keep the grid running smoothly. This delicate balancing act requires a lot of maintenance and management by grid operators to switch from one form of generation to another. If operators do not keep generation and demand balanced it usually leads to brownouts and blackouts.

The scale of the current grid is also a problem. As a side effect of being so large the grid has more space to fail or be disrupted by weather and nature. These seemingly small interruptions can have far reaching consequences. For example, in August of 2003 when a high-voltage line in northern Ohio brushed against some overgrown trees, it automatically shut down. The alarm system failed to notify operators of what happened as other lines were automatically switched off due to the first line’s failure. This resulted in a domino effect leading to Southeast Canada and the Northeastern United States being without power for two days [4]. The loss of power contributed to at least eleven deaths and cost an estimated six billion dollars.

There have been plans and attempts to modernize and improve the grid, but there is only so much that can be done while the grid is supplying power. Most of these plans call for the grid to be converted to a smart grid, which is capable of monitoring and repairing itself [4]. To do this, data would have to be collected on how the current grid operates normally and responds to crises, and a program would have to be created that can replicate the decisions operators make on a daily basis. The large scale of the grid is again an obstacle here, as it is estimated to take fifteen to twenty years to have the proper data, infrastructure, technology, and programming to be able to convert the American power grid to a smart grid [4].

**MICROGRIDS**

The purpose of a microgrid is to create a scaled down model of the main power grid that will create, regulate, and distribute energy to the necessary components that are attached [5]. Microgrids are not a way of trying to get rid of the original power grid, but a way of supplementing the capabilities of the main power grid and providing backup power in emergency cases [6]. A specific case is during blackouts and brownouts when hospitals, researcher centers, military bases, and many other facilities that depend on electricity to function properly must rely on generators that produce minimal amounts of
energy for short periods of time [5]. By connecting these facilities to microgrids, they can continue to function as normal by taking care of patients to the best of their ability or by defending our country without the chance of fatalities [3].

In terms of environmental sustainability, burning fossil fuels not only continues to diminish the limited supply of resources, but also has a negative environmental impact and is found to contribute to global warming [7]. A way to reduce this environmental impact is to reduce the burning of these fossil fuels by becoming less dependent on them. Microgrids offer an alternative by using natural energy and transforming it into usable green energy. Usable green energy is energy input that loads can interpret and use while natural energy is raw energy that is extracted by the wind, sun, water, etc. This energy in turn can be stored, recycled, or used without a negative impact on the environment [8]. In addition, microgrids were designed to use this green energy themselves when the main power grid goes down. There is, however, a way for microgrids to distribute their excess power to the main power grid [8]. Wind, water, and solar energy are typically the natural energy microgrids utilize. These sources are practically unlimited since energy is not created by using up these resources, but by harnessing the energy they already have.

How Do They Work?

Microgrids are made up of different components that mimic a small-scale power grid that transform, distribute, and store energy. The main components are the generator, distributed generators (DG), distributed storage (DS), interconnection switch, control systems, and the loads.

The generator of a microgrid is what provides the grid with its energy [9]. The generator is where fuel is converted into the appropriate form energy that can be distributed to loads. The generator is still operable when the microgrid detaches from the main power grid and is an essential part of an autonomous microgrid. The generators work closely with the DGs, which are small energy sources that are powered by fossil fuels and renewable fuels. Some newer designs of DGs have the capability of reusing excess heat and maximizing their efficiency [9]. DGs are smaller versions of the generator and can provide a constant amount of energy to a load [10]. Figure 3 demonstrates the energy flow through a DG and the basic components and outputs that can be found including the capacitance, inductance, and resistance of the DG. DGs allow the microgrid to have access to different energy producers throughout the grid rather than just one, large centralized generator. Figure 4 depicts a basic interpretation of how microgrids are connected to DGs and loads and where there is current and a voltage drop in the system.

Microgrids can better utilize and switch between controllable and noncontrollable generation. Controllable generation produces energy by burning natural gas, coal, oil, and other burnable material that results in a precise output of energy [11]. Controllable generation can be thought of as energy that is obtained through the burning of natural materials to get energy, but the amount of energy being obtained and extracted is calculated based on what is burned and how much is burned. This is the most common energy source for the main power grid and cannot be reused. Although there is an abundant supply of the resources needed for controllable generation on the planet, it is still limited.

Noncontrollable generation comes from solar and wind energy and its output is more variable than controllable generation [11]. These forms of energy are unlimited on earth, but are unpredictable in how much energy they will produce. Figure 5 compares the different amounts of power that are produced due to different forms of generation. The figure shows the large difference between coal power (gray) and wind power (blue) where the conclusion can be gathered that wind power provided more energy than coal in any given time, even though there is still a higher dependency on coal.

A microgrid’s ability to convert and store this energy efficiently is what makes it unique and why there is a strong push to use them. Since the main power grid cannot use this energy effectively, microgrids are an alternative that also provides green energy and creates less of an environmental impact. There has been discussion about using noncontrollable generation within the main power grid, however the infrastructure and original design do not have the capability of storing the input of energy on a large scale or efficiently.
Comparison of different forms of generation in a week

Any excess energy is then stored in DS, which acts as a bridge for the energy input from the generation to the energy output that is being used [9]. The DS helps extract energy from the microgrid to be distributed to different loads that are unable to connect directly to the microgrid. The main capability and benefit to having the DS as a part of the microgrid is its ability to optimize and enhance the overall ability of the microgrid [9]. Not only does the DS stabilize the DG and regulate its output to minimize fluctuations, but it also stores dynamic energy coming from noncontrollable generation to act as a balance for times when more energy is being produced than being used, or vice versa. The DS also helps to make the energy process run smoothly and try to accommodate for any anomalies or changes [9].

There is also a connection between the large grid and the microgrid where the microgrid can extract energy from the traditional grid when it is functioning properly [12]. If the large grid is down, the microgrid has the capability of severing the connection and running on its own power. The purpose of this interconnection switch is to consolidate the functions of different parts of the energy production such as power switching and protective relaying to minimize the amount of hardware needed to manufacture these grids [9]. The goal is to minimize cost while maximizing functionality.

The control systems are designed to help the microgrid operate as an independent system when needed. They are central, autonomous structures embedded within the microgrid so that when it is disconnected, the generators are turned on as needed to power the loads. The control system monitors the difference of power consumed versus power produced so that it distributes the right amount of energy without wasting any [9]. When independent, the frequency control is the hardest thing to regulate since all the converters and controls must be adaptive to any changes. The frequency control needs to be programmed to use different micro sources and extract enough data to adjust the amount of power it is releasing [9].

Uniqueness of Microgrids

The main difference between current power grids and microgrids is their scale. By reducing the size of a grid, engineers can decrease the possibility of an error occurring on their grid. Figure 6 provides a schematic for a basic microgrid and shows the simplicity of the different elements needed to build one. Smaller grids are also easier to turn into microgrids with control systems because there are typically fewer loads and generators that need to be kept track of. Since there are less components to keep track of, it simplifies the program needed to automatically control the grid.

Once a grid has an automated control system, it is easier for it to use a more even mix of controllable and noncontrollable generation. This is because a computer system can be programmed to identify and react to trends faster than a human operator can. Due to this a microgrid can be programmed to use noncontrollable generation as much as possible and only switch over to controllable generation when necessary [11]. More noncontrollable generation is in line with the national push in the power sector to rely on more green reusable energy. The current grid, however, was not built to handle this variable input, unlike microgrids.

Benefits of Microgrids

Microgrids have the potential to act as a strong adjunct to the main power grid. The purpose of microgrids is to act as a bridge between a facility and the power grid, and as a buffer in case anything happens to the power grid. If something were to happen where energy from the main grid could not reach the loads attached to the microgrid, the connection would be severed and the microgrid would begin to provide energy to the loads [6].

Various countries have already investigated the fluidity of this transition between an isolated system and a connected system. This capability is a reason why there is a push for further development of microgrids; companies are pushing for the implementation of microgrids in locations that would
benefit immensely from their ability to generate power for extended periods of time in emergency cases.

**Implemented Countries**

There are a handful of countries around the world that are testing different models of microgrids to see which ones are worth mass implementation. Some of these countries include Japan, countries throughout the European Union, and the United States.

Although there are many systems that have been established in the United States, there will be a further discussion in the next section about an application on a specific military base and how that has impacted their functionality and productivity.

In Japan, there were various projects that implemented microgrids. In each of the locations, control systems were implemented that had the capability of matching the demand by supplying the needed amount of energy. For each project, the standard margin of error was a set amount that the microgrid had to meet, matching the supplied energy versus the consumed energy [9].

Each of the locations in Japan also had a different focus. In the Aichi project (2003-2007), located at the Central Japan Airport City, energy was made by using fuel cells, photovoltaic (PV) arrays, and batteries. The system used fuel cells and sodium-sulfur batteries to store the energy and had a capacity of 330 kW [9]. These batteries played an important role in being able to match supply with demand for energy. The sodium-sulfur battery was a major controller of the voltage and balancing loads. Figure 7 is a diagram of the Aichi Project, demonstrating the connections between the different parts of the city and how they connect back to the transformer in a unique battery system.

![Aichi Project Diagram](image)

**FIGURE 7 [9]**
**Diagram of the Aichi Project**

In the Kyotango Project for Kyoto Eco-Energy (2003-2007), the facilities were integrated with a utility grid that used a master control system to match the demand and supply of energy creating a “virtual microgrid” [9]. The implemented system could match supply every five minutes based on a predicted demand within a three percent margin of error [9]. This system was being monitored for fluctuations in each period to see if the microgrid could maintain a consistent power quality level.

The Hachinohe Project for Regional Power Grids with Renewable Energy Resources (2003-2007) (Figure 8) featured a system that utilized private distribution lines that connected electricity generated by gas engines, PV arrays, and wind turbines. They used this microgrid at a sewage plant and there were private distribution lines to schools, the city office, and water supply offices [9]. This project was one of the first to depend on the microgrid for a straight week with imbalances in demand compensated for by PV converters. The control systems efficiently met the supply and demand margins with a margin of error rate of three percent [9].

![Hachinohe Project Diagram](image)

**FIGURE 8 [9]**
**Diagram of the Hachinohe Project**

In the European Union, there were two major research projects that were dedicated to the development and testing of microgrids. They were the Microgrids project and the More Microgrids project [9]. The European Union supported this research at an international level and worked together to further their knowledge in microgrids.

The Microgrids project investigated the operation of a single microgrid. By looking closely at a single microgrid, researchers could evaluate and apply different techniques to appropriately monitor the capabilities of a microgrid and maximize its efficiency and productivity [9]. They did this by investigating the control system and considering its interactions with the loads and how it provided them energy. An installation was tested on Kythnos Island, Greece, where the frequency, voltage, and power were monitored on the island in a laboratory to test a smaller scale of the equipment and try different control strategies with the microgrids [9].
The established system had two poles with noncontrollable generation coming from the wind turbines and a battery storage that was connected by a low-voltage line [9]. This setup allowed each pole to operate as an individual microgrid that was connected to the grid separately or to operate connected to each other with the low voltage line and connect to a main grid at one end [9]. Tests were done to try and isolate the transition from a grid dependent system to an independent, isolated microgrid system.

Figure 9 represents how the microgrid could match and mimic the amount of energy the main grid supplies once disconnected and provide the necessary amount of power to the island. The first graph plots frequency as a function of time. The top blue line shows the frequency produced by a normal power grid, the red line indicates the frequency of the island, when the two overlap, that signifies the change of frequency on the island after being connected to a microgrid. All the graphs plot similar findings based on voltage and power also. The conclusion can be drawn that microgrids have the capability of mimicking a power grid and effectively supplying energy to an island independent of a power grid.

In the More Microgrids project, the goal was to increase the generation of energy in electrical networks by applying the concept of microgrids on a larger scale. This was supposed to help set new standards for protocols and implementation of microgrid concepts and technology on a full-size power system. In Bronsbergen Holiday Park in the Netherlands, their traditional three phase 400-V network was connected to a 10kV network with transformers that would distribute 220 A fuses to the three phases with a peak load of 315kW [9]. The project’s goal was to implement a microgrid using smart storage so the park could evaluate its operation and have an automatic isolation and reconnection to the grid.

**FIGURE 9 [9]**
Graphs comparing a system running off and on a microgrid

**FIGURE 10 [9]**
Bronsbergen Holiday Park electrical schematic

**Smart Power Infrastructure Demonstration for Energy Reliability and Security**

The United States military recently completed a three-year project that focused on developing new microgrids. The name of this project was The Smart Power Infrastructure Demonstration for Energy Reliability and Security or SPIDERS for short. This project was a response to the pitfalls of the current power grid already mentioned. It especially focused on how vulnerable the grid is to interference by nature and humans, and its negative impact on the environment. SPIDERS’ goal was to test a microgrid’s ability to operate independently for extended time periods [13]. SPIDERS also had a secondary goal to better manage electrical power generation and consumption at military installations to reduce petroleum demand, carbon emissions, and transportation costs. SPIDERS installed and tested microgrids at three separate military bases with each demonstration becoming more complex: Joint Base Pearl Harbor/Hickam (JBPHH), Hawaii; Fort Carson, Colorado; and Camp H.M. Smith, Hawaii [14].

The first phase at JBPHH, which ran from 2012 to 2013, consisted of a single distribution feeder, two electrically isolated loads, two isolated diesel generators, and an isolated PV array [13]. Two successful tests performed were a fully loaded black start operation, which simulates an emergency
utility failure, and a seamless transition from utility power to microgrid power and back again. These tests provided a base for SPIDERS to develop better systems for the second two phases.

The second phase at Fort Carson, which ran from 2013 to 2014, consisted of three distribution feeders, seven building loads, three diesel generators, and a 1-megawatt segment of an onsite PV array, as well as five bidirectional electric vehicle chargers [13]. This phase focused more on integrating a renewable energy resource (the PV array), electric vehicles, and additional electrical equipment. With the current grid, typical renewable energy sources, such as the Fort Carson PV array, would disconnect automatically during a power outage as a safety feature. The installed microgrid allowed the PV array to still be utilized during a power outage. The electrical vehicles were in use at Fort Carson to try and decrease petroleum dependency on the base. The vehicles were charged by five charging stations hooked up to the microgrid, which allowed SPIDERS to test how the microgrid dealt with changing loads.

The third phase at Camp H.M. Smith in late 2015 was a microgrid that could support the entire base with near instantaneous transition from utility power to microgrid operation [13]. This phase also tested a microgrid acting as a “smart grid.” This means that during times of peak electrical demand on the main grid the microgrid can provide part or all the power needed on the base [13].

These three phases helped the Department of Energy test various microgrid designs to develop an optimal one. In their report, they included the example of a hypothetical base, Camp JCTD, and the changes they would make to it as shown in Figures 11 and 12. The main change that was made was the installation of a Substation Automated Switch System which is what made the base a microgrid. This system allows the base to disconnect from the main grid while also managing variable electricity production. The two other changes made were the addition of new power lines and a power system with a built-in battery to store excess energy.

SPIDERS’ focus on continual power, reduced petroleum demand, more environmentally friendly power systems resulted in a basic outline that can be used to implement microgrids on other military installations. With this outline, the United States military is looking to implement more microgrids on military installations throughout the United States and overseas.

POTENTIAL DRAWBACKS

Although microgrids appear to be the solution for a lot of problems, there have been a lot of setbacks that stop the mass implementation of this technology. There have been debates over privacy, pricing, the resources needed to create these grids, and how well these devices can be mass-produced and
implemented efficiently. In addition, there have been setbacks coming from large power companies whose business would decrease.

The concern over privacy is because of the grid would be able to track the amount of power being consumed and where it was being consumed through the microgrid’s activity. Since sensors are used to track the amount of energy consumed in order to allow the grid to distribute the correct amount of energy, these controls can be tracked via GPS. If microgrids are used in towns or a centralized location with many people accessing them, the average consumer may feel as though someone is watching their power usage [15]. Rather than just having companies watch over the usage over a longer period, the GPS tracking that is put into the systems allow companies to access data that is in real time. This means they can track power usage at any point in a given day. There is not much companies can do with this information, but many people are wary about allowing big companies to have access to this information since other information can be gathered such as when they are and are not home. Although this is an unlikely occurrence and not probable for the microgrids that are being proposed, in the future, taking this step could lead to a bigger development leading to further issues.

Along with the issue of privacy, there is a lack of finances to manufacture these grids. To start the production of microgrids, manufacturers and different corporations need to be willing to invest in the product. Despite the reluctance to invest into the construction of microgrids upfront, there is also pushback from many other companies who would be negatively affected [16]. Power companies and corporations who manufacture solar panels will have a smaller consumer base if microgrids are being implemented and begin to supply the same power their products provide. There will also be a smaller market for home sized diesel generators [16]. These products were created to supply energy to homes in case of disasters. Implementing microgrids will shrink this market since the general population would not need these products. Even natural resource distributors would be at a loss since more people are relying on green energy rather than controllable energy.

Another concern is about the regulation of pricing and access to microgrids. While the consensus has been leaning toward utility controlled pricing for all manufacturers, this puts a disadvantage on low-income consumers [15]. Although there are alternative resources that would be accessible for those who cannot afford microgrids, their implementation is not meant for an individual household, but a small town or community. There is push back that this technology would force those members to have to pay for parts of the installation, technology costs, and the energy they would receive in a disaster even if they cannot afford it since they are still a part of that community [15].

Ethically, the implementation of microgrids does not create immediate issues since their purpose is to be environmentally friendly and economically efficient; however their construction and future dependence may cause shifts in the power industry. The establishment of microgrids will get rid of different companies while slowly monopolizing access to energy, which is not something many critics are keen about.

**SUSTAINABILITY**

The creation and implementation of microgrids takes a lot of investment upfront. However, these microgrids may not be effective if implemented in homes, since a high variable output of energy is not needed [15]. These systems would benefit larger facilities more due to the increased energy needed in these facilities and their need to continue uninterrupted when faced with a loss of power. Microgrids provide a back-up energy source, that is economically sustainable, when needed in an emergency [3]. Facilities who economically suffer in these emergency cases will see a positive return on their investment if they install microgrids.

There are many barriers in the way of the transition to using green energy and weaning off of burning fossil fuels. Some of these barriers include commercialization, price, access, knowledge [17]. The Office of Energy Efficiency and Renewable Energy is pushing to increase research into green energy to try and increase United States’ production of energy systems that can harness green, renewable energy. These efforts can increase awareness and promote the idea of using energy sources other than fossil fuel burning [18]. In the past, there were attempts to close the gap between energy produced by burning fossil fuels and natural energy in Germany. The country’s goal was to increase their natural energy production to 25% of their total energy production, but due to a lack of investment the project failed [19]. It is hard to close a large gap within a short period of time.

Another way to approach the issue is by trying to close the gap a little by decreasing the amount of fossil fuels burned in comparison to the amount that is wasted during the burning process and excess energy that goes unused. One of the big components of the microgrid is the DG where the microgrid stores its excess energy [10]. One of the promising components of the DG is its ability to recycle unused energy and store it or reuse it when generating more energy in the future [9]. Although this does not seem like much, being able to save as much energy as possible and not wasting it can lead to a decrease in burning fossil fuels to prolong the existence of those supplies for as long as possible [20]. The intent is to not only prolong the existence of these natural resources, but to also minimize the carbon footprint left behind that results from the burning of these resources. There is an opportunity to increase the sustainability of the resources and environment. Minimizing negative impacts can increase quality of life and the quality of the environment, which is the basis of sustainability [21].

This also allows some of the research that went into microgrids to continue forward even if there is pushback against their implementation. Technology created from microgrids can provide society tools that will positively benefit...
the environment while minimizing cost to the consumer. Using these concepts would be more affordable than implementing a microgrid, while continuing to minimize the amounts of fossil fuels burned and emitted into the environment.

WHY MICROGRIDS?

Research and investigation into microgrids has been ongoing for the past decade; however, very little progress has been made over the years due to controversy over whether microgrids would be beneficial. Considering the different aspects of microgrids, their intent is to minimize the environmental impact by creating a system that uses noncontrollable generation that does not require the burning of materials, decreasing the emission of toxins into the air. A system that uses noncontrollable generation can also convert and reuse its own power to be efficient and save energy. Not only can microgrids create, store, and reuse their own energy, they can also run independently of the main power grid so if there is a failure in the main power system, the loads connected to the microgrid can still operate normally without any alterations to their systems. This is an effective socially sustainable tool to use on military bases and hospitals where lives can continue to be saved without any casualties or loss of resources due to an emergency.

Although there are reasons for setbacks and fear for moving forward with the project, microgrids have shown promising results in tests by different research facilities located around the world. Microgrids will change the economic systems and infrastructure of the current power grid, but these are just initial obstacles. In the long run microgrids can benefit and help the environment, and different groups of people.

SOURCES

solutions/increase-renewables/barriers-to-renewable-energy.html#1

ADDITIONAL SOURCES


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