SMART GRID

Article Summary:

In its current state, the power grid is mostly non-automated and has little communication between the technology and the power provider. This can prove to be a problem both in terms of safety and also sustainability. Combining knowledge of electrical systems and control technology, the power grid can be updated and greater communication can be established between the various components and controllers. Updating the technology currently used in the power grid can help make electricity production, distribution and consumption safer and more effective. Current technology can also be updated and new technology can be implemented to solve the communication problem and create a better and more interconnected power grid that is robust and efficient.

Introduction

When most people hear the words, 'Smart Grid', what comes to mind? A 'smart grid' of what? In this case, the phrase, 'smart grid' refers to a 'smart' electrical grid. First, lets define what an electrical grid is. An electrical grid is what allows electricity to be delivered from a power plant in the area to a residential or commercial building. The electrical grid powers pretty much everything, from the lights in a house to the charging stations for electrical cars like the Tesla. The electrical grid is an interconnected network that takes large amounts of power generated in power plants and spreads it across the area to the many homes and businesses that rely on electricity. In the United States, the electrical grid spreads from coast to coast. Power generated in Oregon and Seattle can travel down the west coast to southern California. A recent statistic from the Edison Electric Institute, states that there is more than 450,000 miles of high power transmission lines in use (Edison Electric Institute).

The smart grid is the future of the current power grid. At present, the power grid in the US is quite old. The different components and parts have been around for decades. Technology has advanced quite far since then so the next step is to update the grid. This means allowing the different components in the smart grid to 'communicate' with each other via a two-way communication channel. This way the grid can monitor itself for problems and sense when something happens anywhere in the connected smart grid (US Dept. of Energy). This is why it is called a 'smart grid'. It also allows humans to accurately monitor and respond to problems. There will be more information on the smart grid later in this article, but first, a little history about the power grid currently in place.

History of the Grid

In 1879, Thomas Edison created the first electric light bulb. From 1880 to 1882, the Edison Electric Illuminating Company and also the first power plant, the Pearl Street Station, were created. The Pearl Street Station was tiny compared to the scale at which power is generated now. It generated enough electricity to power 800 of Edison's light bulbs using DC (direct current) power. However, DC had a problem, as more light bulbs were connected into the system, the power would fluctuate. Therefore, in 1884, AC (alternating current) was invented. The first AC power station and connected power grid was created in 1886. This system allowed many different devices to be connected at the same time without any large fluctuations to the power.

Over time, the size of the power generation stations grew to handle a larger amount of electrically powered devices. The power grids expanded from a few neighborhood blocks to the size of cities, then from cities to states and from states to the whole of the continental US. In the 1930's, the electrical system that we see today had been established. Currently, the US power grid is split into three different grids: the Western Interconnection, the Eastern Interconnection, and the Texas Interconnection. Despite being three separate grids in name, these three grids are still very much interconnected with each other (US Dept. of Energy).

The electric grid draws is strength from being so interconnected. Like a web of interconnecting roads, if a power outage occurs in one path, another path can be chosen to divert the power and contain the outage to the smallest area necessary. This allows the US power grid to have 99.97% reliability.

Most power grids today around the world follow the same format. The general equation for a standard power grid starts first with the generating power plant. Here, electricity is generated through a variety of ways such as coal, oil, and nuclear, as well as cleaner options such as wind, water, and solar power. The power plants generate very high amounts of electricity that run down through long 'transmission lines' usually across many miles. There are both AC (alternating current) and DC (direct current) transmission lines. In general, AC is the more common method of transmitting power and DC transmission lines require a DC-to-AC converter before they are transitioned into distribution power lines. Before the power can get to the residential and commercial buildings, it has to be 'diluted' and distributed. This dilution takes place because the power in the transmission lines is way too large to be used by normal household appliances. Therefore, a piece of equipment called a 'transformer' is used to step the power down to a voltage that regular appliances can use. These transformers are held in a 'substation', which takes in many different high voltage lines and splits them up into a larger number of lower voltage lines. There are many

different voltages that the substations 'step down'. The higher the voltage, the longer distance is can travel. Therefore, there are multiple 'step down's that the power must take as it goes from a transmission line, to the distribution lines. From the substation, the lines then go to the various houses and buildings that are connected to the power grid each with their own voltage meter to measure their power usage.

However, the current power grid is old. The technology that supports the grid has been around for decades and some parts have never been replaced, just constantly patched up. As the population in the US grows and cities expand further and further, there are larger demands on the power grid. Everyone needs electricity in this current age, and the dependence is only growing. Many power outages that occur can be prevented if the different service providers communicated between each other to balance the electrical load and prevent overloading of certain areas. This is where the smart grid can help!

Benefits of the Smart Grid

There are many benefits to using and developing smart grid technology. By implementing newer and more sophisticated technology, the current power grid can be updated and streamlined. There are a couple of ways that smart grid technology can help!

Many of the technologies that exist today are not computerized or automated. When the grid was first installed in the beginning of the 20th century, not many people were thinking about a long-term plan. Many of the electrical lines were installed as the need for power grew, but there wasn't much planning concerning the placement of power lines or distribution stations. This resulted in a wide web of power lines that are sometimes not the most efficient or coordinated. The scale at which the power grid has grown is enormous and each day more and more users are being added on. By comparison, the amount of new infrastructure that is being built is lessening. This creates a huge load on the existing power grid. Many of the current power components are old and as the power in the lines is increased to a larger and larger load, these older components cannot handle the increased power. This overload of power consumption can lead to an increased number of blackouts and power outages in certain areas with weak or old infrastructure.

This is where the new smart grid technology can be helpful. If components are equipped to communicate with each other and also with a central control center, the electric load can be maintained and balanced. Therefore, if a piece of equipment fails or a transmission line has a fault (where the flow of current is disrupted), sensing equipment can send a message to the central control center. The central control center can then communicate with other transmission lines and equipment around the area to re-route power to

the affected area. This will help isolate and shrink the areas that are affected by power outages. It also helps to accurately locate and detect the exact location of the problem in the system (US Dept. of Energy). That means faster response times to fix the equipment or repair the power line.

This communication between components is an up and coming idea that has spread throughout the technological world. Advances in wired and wireless technology are common now and it feels like every other day, there is a newer, faster and easier way to communicate. With the advent of the world wide web and smartphones, regular people can now talk with each other half way across the world, while also setting the temperature in their home, driving in their Bluetooth enabled car. Smart communication between objects is expected in the present day. If there is communication between the consumer and the electrical grid, this would allow people to be more sustainable as they watch the electrical consumption of their house while their away, or turn off certain appliances that are using too much energy. This could lead to better and more efficient energy consumption by the consumer and businesses, which will lead to less of a strain on the electrical grid, and also less consumption of coal and gas power.

Communication between components in a power grid is very important, but another very important aspect of the smart grid is automation. Automation works together with communication to create a more reliable system. "Traditionally, the operation of the power transmission and distribution grids [is] performed mainly manually" (Strasser, Kastner, 2013). Workers are required to look for meter, breaks in the transmission line and power outages. There are even certain areas where the power companies don't know about an outage until someone calls it in. This is a very slow system as it takes time to locate the power outage and then determine the cause of it. Automation would allow devices attached to the grid to constantly update and report their conditions. They would also be able to be controlled by a central control center. This means that to reroute power from one area to another, ground workers do not have to physically be there to switch the distribution of power. Instead, a central control room or center could flip the switches from wherever they are, almost immediately fixing the outage rather than having to wait for the ground workers to arrive at the scene.

Who does the smart grid impact?

The smart grid will have a huge impact for many people and companies. First and most importantly, it will help the consumers, the people and businesses who rely on the distribution of electrical power to run their lights, heating, computers etc. The extra reliability of the new smart grid and also the fast response time to power disruptions will mean less and shorter power outages. Power suppliers will also be affected. The current technology that is in place relies heavily on manual labor to manually switch and divert

power. Complete automation and communication of the grid would allow companies to save costs of manual work and also provide a safer work environment to their current workers. This would allow power companies to potentially lower costs for their customers.

Smart Grid Implementation: A Case Study

One company that is leading the way in the implementation of the smart grid technology is Southern California Edison, which is based in Los Angeles, California. In 2007, the company started the 'Smart Grid Roadmap' to switch their ageing power grid over to a newer, better and smarter one (SCE, 2010). They outline their definition of the goal, "SCE defines the smart grid as an increasingly intelligent and highly automated electric power system that utilizes technology advancements in telecommunications, information, computing, sensing, controls, materials, in addition to other grid technologies" (SCE, 2010). A link the outline of the plan is provided in the bibliography. SCE planned to have new technologies installed such as advanced sensors and controllers, transformers with superconducting material, and 4G wireless broadband communication to many of their sites.

This plan is to be implemented in five stages that covers the transmission of power, distribution of power and customer related technologies (SCE, 2010). The five stages are: foundation, inform and automate, interactive, and intuitive and trans-active grid. The first stage was mostly an instrument driven stage without much automation or communication. The second stage is focused on the customer. As of the beginning of 2013, SCE has distributed 'smart' power meters to every one of its customers. These smart meters are connected to the internet and can communicate back and forth with the customer. Therefore, users get real time updates of their energy usage through the internet. This is especially helpful in California where the heat in the summer leads to huge amounts of power needed to power AC units and other temperature controlling devices. Customers can now track how much energy their home is using throughout the day and can work to reduce their power consumption to help cut costs and save energy. This is an important step in the communication process as it has connected one part of the smart grid to the internet and therefore allowed for real time dialogue (GreentechGrid). For more information, look at the article related to the 'Internet of Things'. The third stage of the plan will be the full automation of the smart grid. This "Grid 2.0" will consist of better hardware and software technology. Therefore, better power grid components as well as high functioning algorithms and programs that will decide how to react to certain events.

One of the other considerations that SCE has to make is the integration of new 'clean energy' power sources.

Clean Energy and the Smart Grid

There are many types of 'clean' or renewable energy technologies that exist today. One of the most popular is solar power. Many homes and businesses are installing solar panels on their roofs to generate power. These are small-scale energy providers that can usually power part of a building's energy needs. There are also larger scale power generation sites that are called 'intermittent renewables'. This is because they don't generate a constant stream of power. Renewable energy sources, such as solar and wind, are not predictable or constant. Some days might have no wind and be cloudy, while other days might have a lot of sun and wind. This means that there is no way to predict when a surge in power will come. Therefore, it is very important to have smart grid technologies that can update and communicate in real-time. If a power surge spikes, the smart grid has to be ready to distribute that power throughout the system. There are currently many plans that have been proposed to help design a smart grid system that has renewable energy sources. For more information about renewable energy sources, look at the related articles.

In Denmark, there is a large focus on renewable energy source such as solar and wind turbines. These sources of energy are weather dependent, which, as explained above, do not give out a constant stream of power. This can be an issue, because power consumers and customers have a certain set of energy use patterns, which pulls a lot of power out of the grid (Blaabjerg, Guerrero, 2011). At the same time, the wind and solar energy production might not have the same timing to give increased amounts of power to the grid when the customers demand it. Therefore, it is crucial to find a way to create a balance between the two.

A new technology that was just announced is the Tesla Home Battery, the Powerwall. This product is currently not being produced but proposes to allow a home to be smarter in its energy usage. This battery keeps track of the power load on the power grid as well as the power of the sun. By monitoring the power grid, it can track electricity rates and when the load on the electrical grid is high (usually morning and evening), the battery will power the home using energy from its stored power (Tesla Motors, 2015). This will help consumers reduce their energy rates and also help the power grid from becoming too overloaded, which could result in a power outage. At the same time, the battery also monitors the sun's energy and during periods of peak solar power, it will draw clean energy from solar panels to supplement its stored power. This is helpful because the sun usually has the most power at midday, but most families are at work or school, so the solar energy generated isn't used. This battery can store the unused power to then power the house during the morning and the evening when a home's energy consumption is the greatest.

Smart Grid and Developing Countries

For much of this article, the focus has been on the US and how to go forward to upgrade the current power grid to a smart grid. There are also other areas where smart grids can make a large impact. Developing countries have a huge need for better technologies to help to prevent problems such as voltage sags, blackouts, power overloads as well as old equipment. There are many ways that a smart grid implementation can help the current infrastructure have a higher reliability.

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