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Understanding the Smart Grid

A GUIDE FOR COUNTY LEADERS

NACo National Association of Counties

NACo GREEN GOVERNMENT
An initiative of the National Association of Counties

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INTRODUCTION

The electric grid is one of the greatest engineering feats of the 20th century. A complex system of electrical generation, transmission and distribution has ensured that our homes and offices are powered by reliable and affordable electricity. Nearly 40 percent of all energy used in the U.S. is used in electrical generation,[1] and access to electricity has drastically changed how we live our lives in a relatively short period of time. No longer do we use kerosene to light our homes or wood stoves to heat them; it is electricity that lights our buildings, heats and cools our homes and powers our computers and electronic devices.

Yet despite all of the technological advancements over the last 100 years that electricity has enabled, the electric grid has remained relatively unchanged since its inception. This means that there's been little done to improve the reliability, efficiency and security of electricity distribution. Energy companies still rely on customers to let them know when the power goes out, and customers have little idea how much electricity they are using until they receive their energy bill.

The smart grid allows for our grid system to be brought into the 21st century. An interconnected network of devices connected to the grid that relay information to each other and utility companies, the smart grid enables automated processes which allow for more efficient transmission and distribution of energy. New technologies can give customers timely information about their energy consumption. Smart grids can also help counties become more resilient by diversifying their energy portfolios through investments in renewable energy, and can bolster their ability to prepare for emergency situations.

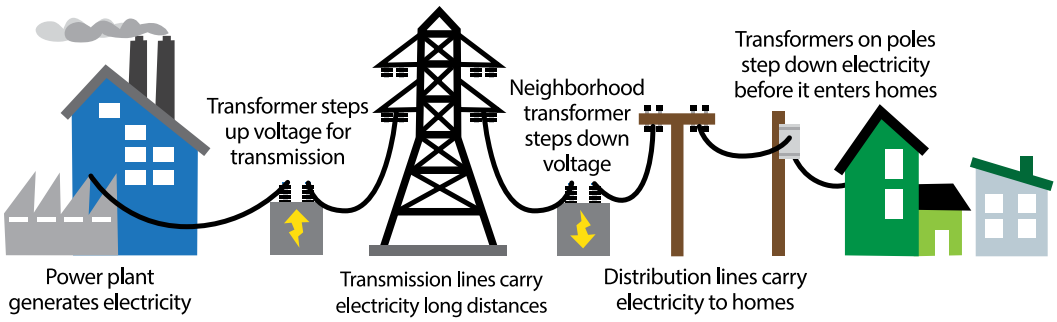
CENTURY-OLD TECHNOLOGY

Little has changed how electricity has been created and delivered to homes and offices since the first electric grid was created in the 1890s.[2] Electricity is generated at a power station[3] and then travels to a transmission substation via high-voltage power lines. From the transmission substation, the electricity travels to a distribution station, where it is then delivered on demand to residential, commercial and industrial customers.

In the early 1900s, there were approximately 4,000 separate electric utility companies, transmitting energy across low-voltage lines to nearby customers.[4] Over the years the demand for electricity grew beyond the capacity of these 4,000 individual utility companies, and the utilities realized it would be more efficient to build larger electrical generation plants and connect their transmission and distribution lines across long distances. High-voltage lines were developed to increase transmission speeds and minimize the loss of electricity across these distances. Today, a transmission line owned by one utility might be used by multiple utilities to provide electricity to customers across wide parts of the country.

As more and more utilities began connecting their electrical systems, three major power grids emerged that serve the lower 48 states: the Eastern Interconnected System (which serves states east of the Rocky Mountains); the Western Interconnected System (serving states in the Rocky Mountains and west); and the Texas Interconnected System (serving most of Texas).[5] These three interconnected systems serve more than 3,200 electric utilities[6] and connect more than 9,200 electric units across 300,000 miles of transmission lines.[7]

ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION.



Source: U.S. Energy Information Administration, http://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

The growth of these interconnected systems reflects the growth in the demand for electricity. From 1950 to 2011, the U.S. population grew from 151 million[8] to 311 million, more than doubling in size.[9] During that same time span, U.S. energy consumption increased more than 13 times to nearly 3.856 billion kilowatt-hours.[10] In 2011, residential customers were the largest segment of users, at 37 percent, followed by commercial customers at 34 percent, industrial customers at 26 percent, and the transportation sector using the remaining 3 percent.[11] The majority of electricity used by residential customers goes toward powering air conditioning, space and water heaters, refrigerators and lighting.[12]

WHAT IS THE SMART GRID?

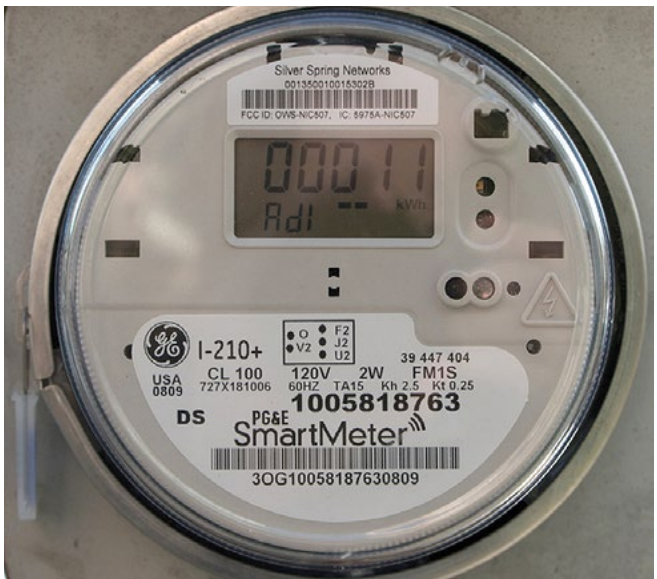
While access to electricity has enabled major advancements in technology, which in turn has driven an increase in the demand for electricity, little has changed in the way electricity is generated, transmitted and distributed to consumers. The term smart grid refers to new technology that brings the century-old method of electricity generation and distribution into the 21st century through computerized automation and control.

The smart grid builds upon the current grid system in the U.S., but uses digital technology that enables for two-way communication between a utility and its customers. The ability for two-way communication creates an automated and widely distributed electricity network that can "monitor, protect and automatically optimize the operation of its interconnected elements."[13] This new automated network allows for utilities to respond more efficiently to customer demand, and enables consumers to take more control over their energy usage through increased access to information.

The smart grid is composed of a number of interconnected components that monitor use and share real-time data. One of the most important parts of the smart grid is smart meters. Like the regular meters connected to homes and offices, smart meters collect and provide utilities information about energy use and consumption, but provide these data more frequently and can also communicate with appliances and programs inside homes and workplaces. Smart meters enable both utilities and consumers to know in real-time how much energy is being used.

Much like how smart meters can communicate between utilities and consumers, smart transmission and distribution devices can allow utilities and transmission and distribution centers to communicate with one another. This communication can help utilities spot inefficiencies in the transmission and distribution processes, ultimately leading to significant cost savings for the utility and reduced electricity rates for the consumer.

Large- and small-scale smart grid development is occurring in nearly every state in the U.S., with more than 200 projects by private and public utilities currently in use or development.[14] The federal government, through the Energy Independence and Security Act of 2007 and American Recovery and Reinvestment Act of 2009, has made it a priority to spur development of smart grids in the U.S. In 2011, 99 projects in 43 states across the U.S. received over $3 billion in funding for development from the Smart Grid Investment Grand Program, part of the American Recovery and Reinvestment Act of 2009.[15]



A typical smart meter.

Source: Flickr user christianhaugen

Solar panels help provide the Santa Rita Jail with renewable energy via the jail's microgrid. *Source: Alameda County, Calif.*

CASE STUDY

Santa Rita Jail Microgrid

Alameda County, Calif.

While many counties will work with utility companies to help develop smart grid capabilities, some counties are demonstrating their ability to take the lead in energy innovation.

The Santa Rita Jail in Alameda County, Calif., is the third largest county jail in California and the fifth largest in the nation, and houses 4,000 inmates in 18 buildings across 113 acres. Powering the facility requires a continual feed of 3 megawatts of electricity, and due to the nature of the facility, any disturbance in the electrical supply could threaten the safety of the jail's staff and inmates.[16]

Alameda County recognized the need to ensure a constant supply of energy to power the jail, and saw the opportunity that smart grids can play in providing reliable energy supply. The county partnered with Chevron Energy Solutions and federal, state and local agencies to develop and build the $11.7 million smart grid project, completed in 2012. The microgrid (a localized smart grid) will sustain power at the jail if its normal connection to the utility grid is interrupted, and will also help reduce energy costs through efficient operations.

To mitigate the risk of loss of electricity, the jail's microgrid works in tandem with the regular utility grid, but will automatically disconnect in a power failure and operate independently.[17] The county installed a 1.2-megawatt solar panel system on the jail's roof, five wind turbines, and a 1-megawatt cogeneration plant that allows for waste heat recovery to reduce energy usage. In case of a power failure, a 2-megawatt energy storage system is able to store enough electricity for the jail to continue operating for up to eight hours until power is restored or conventional generators need to be used. The microgrid also enables the jail to buy power from the local utility during off-peak hours (when the rates are lower) and store the energy for use during the peak hours. The county expects the microgrid to save it more than a quarter million dollars per year in energy costs.

The microgrid has enabled Alameda County to operate facilities in a way that not long ago was unthinkable. As County Supervisor Keith Carson notes, "With the Santa Rita Jail microgrid, Alameda County is taking advantage of cutting-edge technology to increase efficiency and mitigate environmental impacts. The smart grid allows us to take advantage of fuel cell, solar and wind renewable energy sources that protect jail staff and inmates with a source of reliable energy and save taxpayers more than $260,000 per year."

BENEFITS OF THE SMART GRID

Improved Service

While the process of electrical generation, transmission and distribution has been used for over 100 years, one of its major limitations is the inability for two-way communication. When the grid was set up, it was designed just for electricity to flow from the utility to customers. If the power went out, the utility had no idea until a customer would call it up.

With the smart grid, devices in a home or office or along the transmission and distribution lines can immediately alert utilities to when and where the power went out, enabling them to promptly address the issue. Utilities can also use the smart grid to let them know the condition of the equipment, allowing them to catch any failing devices before they wear out, and to be able to plan more effectively in replacing equipment.[18]

Smart grids also enable utilities to monitor and stay on top of electricity demand. As demand increases, utilities need to work harder to produce more electricity, which can put stress on the existing infrastructure and cause issues with efficiency and reliability. Utilities can use the smart grid to track demand across the grid in real time to produce extra electricity only when needed.

Improved Customer Control

Smart meters can provide customers with real-time information about their energy usage and costs. Currently, customers are unaware of how much energy they use until they receive their electric bill from the utility. Because of this, it is hard for consumers to understand the impact their behavior can have on energy use and associated costs.

Applications on smart phones, tablets and websites can display current energy usage, allowing customers to compare their energy usage to their historical data. For example, they could see instantaneous changes in energy use from turning on a television, or compare the amount of energy used for lighting after switching out incandescent light bulbs for more efficient compact fluorescent bulbs. The information provided from smart meters and applications can enable customers to change their behavior, incentivize them to use less energy overall and shift their use of electricity during times when it is cheaper.

Smart appliances can also connect to the smart grid to help consumers save energy. For example, thermostats connected to the smart grid can adjust temperature and energy usage throughout the day to use less energy during peak demand hours when the cost of electricity is at its highest. Appliances like this will help consumers automatically use less energy in addition to any personal changes in consumption.

Appliances connected to the smart grid can provide real-time information on energy usage.

Source: Flickr user digitpedia

The ribbon-cutting ceremony at a smart house at the Los Alamos Demonstration Smart Grid project. The project will help researchers understand how homes and appliances connected to the smart grid can operate more efficiently. *Source: Los Alamos County Department of Public Utilities*

CASE STUDY

NEDO Demonstration Smart Grid Project

Los Alamos County, N.M.

Los Alamos County, N.M., is providing insight into the future role counties can play in providing clean energy to its citizens. The county's Department of Public Utilities (DPU) currently produces more than 30 percent of its electricity from renewable hydroelectric power,[20] but it wanted to know how it can successfully use renewable energy to provide a significant portion of residential communities' energy need. Not everyone can afford to install solar panels on his or her property, but through a smart grid, the county might be able to provide renewable energy to entire neighborhoods.

In 2009, DPU partnered with the Los Alamos National Laboratory and Japan's New Energy and Industrial Technology Develop Organization (NEDO) to create the Los Alamos Demonstration Smart Grid Project. The project includes 1 megawatt of photovoltaic generation, 1.8 megawatt/8.3 megawatt-hours of battery storage, a demonstration smart house equipped with smart products and appliances and a micro energy management system that will help control functions on the grid and monitor electricity supply and demand. The electricity generated powers a Los Alamos neighborhood of about 1,600 homes fitted with smart meters and appliances, and will test how DPU can reduce demand during peak hours, especially on hot days.[21]

Project members hope to learn how they can translate lessons learned from the demonstration smart grid to more large-scale installations across the U.S. Though research on the project is ongoing, the project partners are demonstrating that using a micro energy management system and batteries can stabilize solar electricity output for residential customers, and that a micro energy management system can reliably forecast energy demands, helping the utility plan for energy production. Researchers are also evaluating how customers with smart meters reduce their energy usage or shift their usage to off-peak hours based on information they receive.

The research being done at the Los Alamos Demonstration Smart Grid will not only help provide clean energy to county residents, but will help advance renewable energy integration worldwide. As John Arrowsmith, Utilities Manager for the Los Alamos Department of Public Utilities, notes: "The demonstration project with NEDO has enabled the county to increase the renewable energy sources in its generation portfolio while participating with our largest customer, the Los Alamos National Laboratory, in important research to solve global challenges."

Integration of Renewable Energy

One of the major benefits of smart grid technology is its ability to integrate with renewable energy. Electric utilities aim to ensure that electricity supply meets the demand. Renewable energies are able to increase the number or sources for providing enough electricity to meet demand, but unlike coal—which can be used on a continual basis for electricity production—some renewable sources like solar and wind can only generate electricity when the sun is out or the wind is blowing.

The smart grid allows utilities to monitor the variation in electricity produced by solar and wind projects, and switch to other sources of electricity to meet demand when renewable energy output dips. Advancements in technology have also begun to enable battery systems connected to the grid to store excess electricity produced by solar and wind to be used when output fluctuates.[19]

Additionally, the smart grid can enable non-electric utility producers of renewable energy to sell back excess energy. Due to the smart grid's two-way nature, excess electricity produced by solar panels on residential, commercial and county buildings, for example, can be sold to utilities and added back into the grid.

The smart grid can help integrate renewable energy, such as windpower, to help meet a county's energy needs.

Source: Shutterstock

SMART GRIDS AND THE COUNTY

While smart grids provide benefits to utility companies and consumers, they also provide a number of benefits to counties. Smart grids can provide a county the opportunity to strengthen its energy assurance program (EAP). EAPs allow counties and local governments to help create reliable and secure energy infrastructure, and are a tool to help increase county resiliency by reducing vulnerability to extreme weather events and outdated infrastructure, and by being able to quickly restore electricity service after outages.[22] Though counties may not be the direct provider for energy to customers, they are responsible for working with energy providers and other stakeholders during times of emergency to minimize problems caused by outages, ensuring public safety and enabling quick recovery.

During outages, smart grids can help speed up notification time to the public about grid conditions. During an outage with the current grid, utilities are only made aware of an issue when customers report them, and depending on the circumstances, it can take several hours to days, even, for the utility to fully understand the nature of the problem. Due to their two-way communication capability, smart meters provide utilities with near instantaneous reports of issues or outages, and can provide updates about restoration efforts. Counties can be made aware of issues faster, allowing them to be better situated to respond to emergency situations, if needed.

In addition to providing opportunities for counties to better communicate with the public about issues with the grid, smart grids can also help counties be more prepared for emergencies and disasters.[23] The data made available through the smart grid can allow counties to understand the energy needed to power communities, as well the amount needed to maintain power at critical facilities. Knowing this information before an emergency occurs can help the county develop emergency plans for various scenarios where power is disrupted.

While many counties don't directly provide electricity to consumers, counties have the ability to work with the local utility to research and invest in upgrading the grid, and help utilities secure funding opportunities. In December 2013, the U.S. Department of Agriculture (USDA) announced the award of $1.8 billion in grants to rural electric utilities to help upgrade rural electric utility infrastructure. These awards include nearly $45 million designated for investments in smart grid technology, and $73 million will support renewable energy projects.[24] For more information about these awards, visit the USDA Rural Utilities Service program website at *www.rurdev.usda.gov/utilities_lp.html*.

STEPS COUNTIES CAN TAKE TO UPGRADE THE GRID:

- One opportunity for counties to be involved in implementing smart grid programs is to **develop community outreach programs** that can teach consumers the best practices for smart energy consumption. Many utilities offer the opportunity for customers to upgrade home meters to smart meters. By helping consumers understand how to use information available to them through smart meters, consumers can then change their habits to reduce energy usage overall, but also during times of high demand when peak rates apply.
- Counties can also **update their planning and zoning ordinances** to improve the siting and permitting of renewable energy systems like solar panels and wind turbines. Making it easier to develop renewable energy can allow more clean energy to be generated and distributed through the smart grid.
- Lastly, counties can **reduce energy usage at county facilities by installing smart meters** and other appliances. In 2013, Sacramento County, Calif., in collaboration with the Sacramento Municipal Utilities District, installed smart thermostats in county buildings. These smart thermostats automatically control the chillers for cooling more than two million square feet of county-owned buildings, and allow the buildings to reduce energy use by 400 kilowatt-hours.[25] The county expects to annually save an estimated $240,000 in energy costs and reduce carbon emissions by nearly 1,000 metric tons.

ADDITIONAL RESOURCES

Alameda County, California

- Alameda County: *http://www.acgov.org*
- Alameda County Santa Rita Jail Microgrid: *http://www.acgov.org/smartgrid.htm*

Los Alamos County, New Mexico

- Los Alamos County: *https://www.losalamosnm.us/Pages/Home.aspx*
- Los Alamos County Smart Grid: *https://www.losalamosnm.us/utilities/Pages/LosAlamosSmartGrid.aspx*

Smart Grid Information Clearing House

- Smart Grid Information Clearing House: *http://www.sgiclearinghouse.org*
- Smart Grid Project Database: *https://www.sgiclearinghouse.org/ProjectList*

U.S. Department of Energy

- U.S. Department of Energy Smart Grid Center: *http://www.smartgrid.gov*
- Smart Grid 101 for Local Governments: *http://www.smartgrid.gov/sites/default/files/doc/files/Smart_Grid_101_for_Local_Governments_201112.pdf*

U.S. Energy Information Administration

- U.S. Energy Information Administration: *http://www.eia.gov*
- Energy in Brief: *http://www.eia.gov/energy_in_brief/article/power_grid.cfm*

U.S. Environmental Protection Agency

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- Smart Grid and Clean Energy for Local Governments: *http://www.epa.gov/statelocalclimate/documents/pdf/background_paper_smartgrid_4-29-2010.pdf*

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About the National Association of Counties

The National Association of Counties (NACo) is the only national organization that represents county governments in the United States. Founded in 1935, NACo assists America's 3,069 counties in pursuing excellence in public service to produce healthy, vibrant, safe and resilient counties. NACo promotes sound public policies, fosters county solutions and innovation, promotes intergovernmental and public-private collaboration and provides value-added services to save counties and taxpayers money. For more information about NACo, visit *www.naco.org*.

About the Green Government Initiative

Since 2007, the NACo Green Government Initiative (GGI) has served as a catalyst between local governments and the private sector to facilitate green government practices, products and policies that result in financial and environmental savings. GGI provides comprehensive resources on high-priority topics including renewable energy and energy efficiency, air and water quality, transportation and land use, sustainable purchasing and procurement and waste reduction.

Through the initiative, NACo:

- Develops strategies to save counties money while reducing their environmental impact,
- Educates counties on techniques for implementing green strategies,
- Provides tools for counties to educate their communities on environmental initiatives,
- Promotes environmentally preferable purchasing, and
- Facilitates an open exchange with the private sector.

For more information, visit *www.naco.org/greencounties*.

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