Powering the nation: Smart grid careers

Our nation's energy needs have increased tremendously, especially in the last few decades. But the basic system for transmitting and distributing electricity hasn't changed in more than a century. Modernizing the system through "smart grid" technology not only improves the way we store and get power, it provides jobs for workers who have the right training.

Population growth, an increase in home size and air conditioning, and the proliferation of computers and other electronics are among the factors driving growth in demand for electricity in recent decades. According to the U.S. Department of Energy, since 1982, growth in peak demand for electricity has outpaced growth in power transmission by almost 25 percent each year.

The current power grid—the network for distributing electricity from the power source to consumers—evolved during the late 19th and early 20th centuries. The grid was designed to route power to consumers through high-voltage lines from a small number of powerplants located far from population centers. The amount of power generated at any time was based on overall demand and did not account for fluctuations in use. Because of the high cost and risks associated with making large-scale changes, however, little had been done to the existing power grid since it was first created.

Until now. Smart grid technology (the smart grid), in early stages of implementation nationwide, allows utilities and other electricity suppliers to constantly monitor electricity flow and adjust its distribution for maximum efficiency. In addition, the smart grid makes better use of energy generated from alternative sources, such as from solar panels, wind turbines, and other energy-generating systems, through improved storage and transmission.

This article describes career fields related to the smart grid. The first section explains our electricity transmission by the current power grid and how the smart grid improves upon that method. The second section briefly describes some of the key occupations in the smart grid, including those in the computer; engineering; installation, maintenance, and repair; and production occupational groups. The third section summarizes the credentials, such as education, training, and certification or licensure, that you need to work in these occupations. Sources of more information are provided at the end.

From functional to efficient: Updating the grid

The electricity we use comes from a variety of sources, including coal, nuclear power, and natural gas. Powerplants generate electricity from these sources and transmit it to homes, businesses, and other structures, such as streetlights. In the grid system, electricity moves from powerplants through high-voltage lines to distribution stations and on to consumers.

Smart grid technology improves upon the current grid. Modernizing the current power grid should create a more efficient, reliable, and flexible system for supplying electricity.

The current power grid

The current power grid is made up of networks that include wires, switches, transformers, substations, and other equipment. Originally built as local grids, these networks eventually were connected into a national power grid during the 1960s. But this system was based on demand from large population centers as a whole and is unreliable for current needs. For example, when electricity demand increases during certain times of the year, some powerplants can't keep up; the result may be brownouts or blackouts, the partial or full loss of power.

Over the past 50 years, the current power grid has not kept up with changes in demand based, in part, on advances in technology, such as household appliances and lights that shut down during peak periods of electricity use. The current grid is inadequate for development, too: it cannot adequately

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accommodate the increased use of alternative power sources, including solar and wind energy, which have intermittent supply.

The smart grid

The smart grid is a digitally enhanced network that uses computer-based remote control and automation to increase the efficiency of the current power grid. These systems employ two-way communication technology and computer processing used in other industries, such as telecommunications.

A key feature of the smart grid is automation that allows the utilities to adjust and control each device from a central location. Each device on the smart grid can gather data and communicate digitally with the utility operations center. The smart grid also helps power generation move toward the use of a more green technology.

Green technology. The smart grid is vital to a green economy because it promotes viability of environmentally friendly technologies, such as renewable energy sources. For example, smart grid technology allows more electricity to be generated by intermittent sources, such as wind and solar power, and to switch to traditional sources, such as coal and natural gas, when renewable-energy plants cannot provide enough power.

Technologies that make up the smart grid include advanced metering infrastructure, commonly known in the industry as AMI; electricity distribution systems; electricity transmission systems; and energy storage capabilities. Together, these technologies enable providers to adjust the amount of electricity generated and to redirect it to meet changes in demand throughout the day.

Advanced metering infrastructure allows electricity providers to monitor power use continuously. Smart meters installed in homes and businesses measure real-time electricity use and transmit the data to the provider, which can modify power generation accordingly.

Electricity distribution systems provide real-time monitoring and intelligent computer control. Monitoring and control allow operators to detect problems with the grid, such as

Smart grid technology promotes the use of renewable energy sources, such as solar power.

power outages, and to dispatch repair crews immediately to minimize the time consumers are without power.

Electricity transmission systems allow power to be sent to areas where it is needed most, when it is needed most. These improved transmission systems divert electricity from areas of low demand and reroute it to areas with high demand, as needed.

Energy storage capabilities are an important part of integrating renewable power sources. Because renewable sources do not supply electricity continuously, they may not be effective during certain times of the day. For example, if the wind is blowing at night, wind turbines produce power that is unlikely to be used during this low-demand period. But improved energy storage prevents this energy from being wasted, by providing a way to save the excess for use when demand is higher.

Putting smart grid into practice. Smart grid technologies are beginning to be used on electricity networks from powerplants to substations and on to consumers in homes and businesses.

Federal law supports modernizing the current power grid to meet future electricity demand. Among other provisions, the law authorizes smart grid technology research, development, demonstration, and funding. The U.S. Department of Energy has a number of projects and studies related to smart grid development, as does nearly every state.

However, states are inconsistent in smart grid application. For example, according to the MIT Technology Review, states such as California and Texas have begun to install equipment but have not yet completed the network required for the grid to fully function. As of June 2013, only Florida has a large-scale, comprehensive smart grid operating.

Advanced metering infrastructure technology is furthest along in implementation. According to the U.S. Energy Information Administration, electric utilities had installed more than 37 million smart meters in the United States in 2011. Most of these—about 33.5 million—were residential installations by investor-owned utilities.

Improved energy transmission systems allow electricity to be rerouted to where it is needed most.

Occupations in smart grid work

According to the U.S. Department of Energy, companies producing technology and offering services related to the smart grid include communications firms and new and established technology firms.

Implementing the smart grid requires many workers in various occupations. And after the smart grid is set up, other workers will be needed to operate and maintain it. Work related to the smart grid is expected to result in about 280,000 new positions, according to energy consulting firm DNV KEMA. These jobs span several occupational groups and include engineers, technicians, and construction workers. In addition to employment with utilities, many workers will be hired by suppliers and contractors.

The U.S. Bureau of Labor Statistics (BLS) does not collect employment or wage data specifically for occupations related to the smart grid. The table below shows the May 2012 employment and wages for occupations related to smart grid work, primarily in the electric power generation, transmission, and distribution industry.

Computer and mathematical occupations

One of the defining characteristics of the smart grid is increased computer control and automation. As a result, computer systems analysts, network and computer systems administrators, operations research analysts, and software developers are needed to create, operate, and maintain the computer systems that the smart grid uses.

Workers in these occupations spend most of their time indoors working with computers. They are usually employed by utilities, technology firms, or government agencies

Employment and wages for selected occupations related to the smart grid, May 2012[1]

Occupation	Employment	Median annual wage[2]
Computer and mathematical occupations		
Computer systems analysts	2,090	$88,820
Network and computer systems administrators	1,720	74,930
Operations research analysts	380	75,170
Software developers, systems software	580	91,050
Architecture and engineering occupations		
Electrical engineers	14,780	85,350
Electronics engineers, except computer	310	75,980
Electrical and electronics engineering technicians	6,840	65,160
Installation, maintenance, and repair occupations		
Electrical and electronics repairers, powerhouse, substation, and relay	16,520	69,120
Electrical power-line intallers and repairers	57,540	65,690
Telecommunications equipment installers and repairers, except line installers	130	70,370
Production occupations		
Electrical and electronic equipment assemblers[3]	197,500	28,810
Power distributors and dispatchers	6,740	71,200
Power plant operators	30,060	67,010
Other occupations		
Electricians	6,810	61,160
Meter readers, utilities	8,860	44,380
Urban and regional planners	50	71,180

[1] BLS does not have employment and wage data specifically for smart grid occupations. Except where specified, these data are for occupations in the electric power generation, transmission, and distribution industry. Data are for wage and salary workers only and do not include the self-employed.

[2] Data are for the United States as a whole; wages vary by employer and location. In addition, these wage data do not include benefits.

[3] Data are not available for electrical and electronic equipment assemblers in the electric power generation, transmission, and distribution industry. These data represent employment and wages for the occupation as a whole.

Source: U.S. Bureau of Labor Statistics (BLS), Occupational Employment Statistics.

and may work in offices or in a control center. Network administrators may be required to travel to different locations to troubleshoot and fix problems.

Computer systems analysts have a variety of roles. They may specialize in helping select the appropriate system hardware or in developing and fine-tuning systems. They could work with computer programmers to debug, eliminate errors from, or do in-depth testing of the systems. Because the smart grid relies more on computer control than the current grid, computer systems analysts will be needed to help build these systems and manage them once they are operating.

Network and computer systems administrators install and maintain an organization's computer systems. Many components of the smart grid depend on reliable computer networks to operate, so these workers are needed to ensure that computer systems function properly and that problems are fixed rapidly.

Operations research analysts formulate and apply analytical methods from mathematics, science, and engineering to develop and interpret information. They reduce the complexity of resource management to help utilities make better decisions and to improve efficiency. Using sophisticated software, these workers solve problems and are often involved in planning and forecasting. For example, they may predict future electricity needs so that power generation and transmission capacity is developed before it is needed.

Software developers design, test, and evaluate the applications and systems that make computers work. The computer systems that run the smart grid require specialized software. Software developers are needed to create this software and to modify it to suit each electric utility's individual needs.

Architecture and engineering occupations

Engineers apply science and mathematics to develop economical solutions to technical problems. Many engineers specify requirements and then design, test, and integrate components to produce designs for new products. After the design phase, engineers evaluate a design's effectiveness, cost, reliability, and safety. Electrical engineers, electronics engineers, and electrical and electronics engineering technicians are needed in smart grid work.

Most engineers and engineering technicians work indoors, usually in an office or laboratory. For smart grid work, they use computers extensively to produce and analyze designs and for simulating and testing systems. Engineering technicians assist engineers with designing, developing, and testing quality-control products and processes. Engineers and technicians are typically employed by electric utilities, government agencies, or construction firms.

Engineers in smart grid jobs use computers to produce and analyze designs.

Electrical engineers design, test, and supervise manufacturing and construction of electrical equipment, including power generation, communications systems, control, and transmission devices. In smart grid work, electrical engineers typically focus on power generation and supply.

Electronics engineers work on applications for a range of smart grid technologies, including control systems that monitor how much electricity is being used at certain locations and systems that monitor electricity produced at generating stations, solar panels, or wind turbines. They also design and develop control systems for powerplants.

Electrical and electronics engineering technicians help design, develop, test, and make electrical and electronic equipment. Technicians may test and evaluate products, using measuring and diagnostic devices to adjust and to repair equipment. Many engineering technicians assist engineers in researching and developing electric and electronic equipment for smart grids.

Installation, maintenance, and repair occupations

Telecommunications workers install, maintain, and upgrade the communications equipment that controls a smart grid. They are employed by powerplants and utilities, and job tasks vary based on where they work. For example, line installers and repairers employed by utilities maintain low-voltage distribution lines and equipment such as transformers, voltage regulators, and switches.

Electrical power-line installers and repairers build and maintain the smart grid.

Line workers travel with a crew to maintain smart grid transmission lines and towers throughout a region. Some occupations are dangerous because workers must be close to high-voltage electricity or high above the ground to do certain job tasks.

Electrical and electronics repairers fix equipment used in generating and delivering electricity. Electrical equipment generally refers to what is used to generate or supply electricity, including transformers and switches; electronic equipment is used to control devices, such as those that monitor and adjust the flow of electricity based on demand in a given area. Repairers troubleshoot problems and fix damaged or broken equipment.

Electrical power-line installers and repairers build and maintain the smart grid. They routinely work with high-voltage electricity, which requires extreme caution. They inspect and test power lines and other equipment and install power lines between poles, towers, and buildings.

Telecommunications equipment installers and repairers have a range of duties that varies by the type of work they do and where they work. Most work outdoors to install and repair smart grid equipment that transmits data to utility control centers and computers that monitor electricity supply and demand.

Production occupations

Operating the smart grid requires new equipment for generating plants and substations to handle increased capacity. Other plants and substations must be upgraded with smart grid technologies. Equipment assemblers, power distributors and dispatchers, and power plant operators are needed to prepare and control these smart grid facilities.

These workers spend time indoors in factories, offices, operations centers, or powerplants.

Electrical and electronic equipment assemblers construct the equipment used in the smart grid. They assemble components of smart meters and other equipment used in the real-time monitoring of electricity demand. Some of their job tasks are repetitive.

Power distributors and dispatchers control the flow of electricity through transmission lines to industrial plants and substations, which in turn supply residents and businesses. They operate electrical current converters, voltage transformers, and circuit breakers. They also monitor other distribution equipment and record readings at a map board, a diagram of the smart grid that shows the status of transmission circuits and connections with substations and industrial plants.

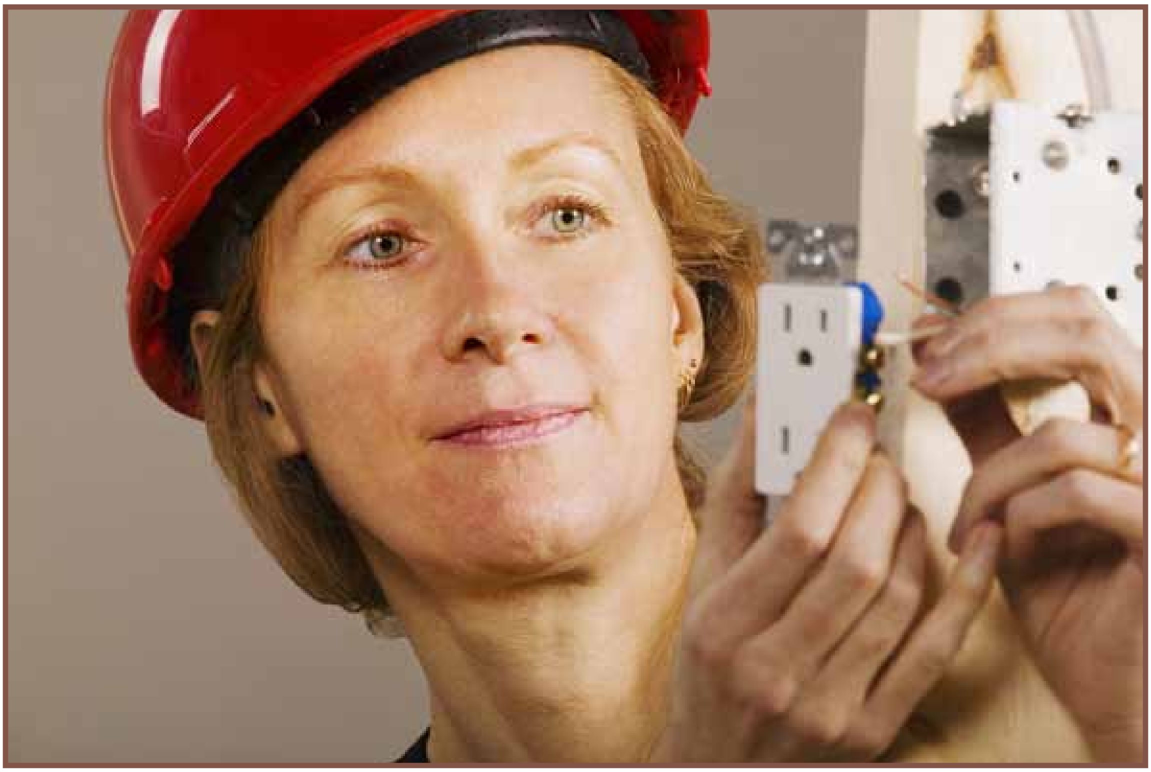
Power plant operators in power-generating plants control and monitor equipment, such as boilers, turbines, generators, and auxiliary equipment. They regulate the output from generators and monitor instruments to adjust electricity flow from the plant. When demand changes, power plant operators communicate with dispatchers at distribution centers to match production with system loads and alter electricity output, as needed.

Other occupations

Among the other occupations in smart grid work are electricians, meter readers, and urban and regional planners. Electricians install smart meters and other equipment at homes and businesses. Meter readers' occupation will undergo transformation with smart grid implementation, and their jobs are likely to change. Urban and regional planners are important in the analysis and arrangement of the power grid.

Electricians install and maintain electrical systems for homes and businesses, working with electrical wiring and control equipment. Electricians who work with smart grid technologies install smart meters and must be familiar with smart appliances, lighting, and other technologies associated with the smart grid.

Electricians usually work indoors, often in cramped spaces, and may spend a lot of time



Electricians in smart grid jobs must be familiar with other technologies associated with the smart grid.

kneeling, lifting, or standing. Most electricians work for electrical contractors and other wiring installation contractors, but some are self-employed.

Meter readers will be heavily affected by the implementation of the smart grid. Meters for the current grid are attached to houses and other buildings, where they must be periodically read and recorded by a meter reader. But the smart grid relies on advanced metering infrastructure—automation that does not require meter reading as it currently exists. As a result, meter readers need to be retrained for another occupation.

Meter readers work mostly outdoors, driving or walking around neighborhoods. They are employed primarily by utilities.

Urban and regional planners develop long- and short-term plans for land use and community growth. They recommend to local officials infrastructure and zoning locations, which requires forecasting population needs. In smart grid work, they determine a community's electricity requirements based on its industries, population, and employment and economic trends. This information helps local and regional utilities in developing the smart grid.

Most urban and regional planners work in offices, usually for state or local governments.

Training for smart grid jobs

To prepare for smart grid jobs, some workers, including electrical engineers, already have many of the skills they need but will require additional training to transition to the new technologies. Other workers, such as meter readers, need extensive retraining to gain more diverse, higher level skills for new smart grid jobs.

This section describes the basic credentials needed for workers in occupations covered in the previous section. Specific training required for smart grid positions vary by employer.

Computer occupations

Training for workers in computer jobs span a range of requirements, from professional certification through a graduate degree—sometimes within a single occupation.

Computer systems analysts and ***network and computer systems administrators*** often need a bachelor's degree, although an associate's degree or professional certification plus work experience may be adequate for some jobs. Most systems administrators begin as computer support specialists before advancing to administrator positions.

For some smart grid jobs, workers may already have many of the skills they need, such as proficiency with computers.

Network and computer system administrators can enhance their employment opportunities by earning certifications, which are offered through product vendors, computer associations, and other training institutions. Many employers regard these certifications as the industry standard and sometimes require them. Because technology changes rapidly, computer specialists must complete periodic training to stay abreast of the latest developments.

Operations research analysts must have a bachelor's degree that includes extensive coursework in mathematics and other quantitative subjects. But many employers prefer to hire candidates who have a master's degree in operations research, management science, or a related field—such as computer science, engineering, business, applied mathematics, or information systems. Dual graduate degrees in operations research and computer science make candidates especially attractive to employers.

Continuing education is important for operations research analysts. Keeping up to date with technological advances, software tools, and improvements in analytical methods is vital for maintaining problem-solving skills.

Software developers commonly need a bachelor's degree, although for some positions employers may prefer to hire candidates who have a master's degree. For other jobs, an associate's degree or certificate is adequate.

Employers favor job candidates who have relevant skills and experience. Workers who keep current with the latest technology usually have the best opportunities for advancement.

Engineering occupations

Engineers typically have a bachelor's degree in engineering. Because of the complexity of some systems, however, a significant number of employers require candidates to have a master's or doctoral degree. Engineers are expected to complete continuing education and to keep up with rapidly changing technology.

Certifications are usually required and depend on the systems used by a particular manufacturer or utility. Licensure as a professional engineer is often required, depending on an engineer's specialty.

Entry-level engineers may be hired as interns or junior team members and work under the supervision of senior engineers. As they gain experience, entry-level engineers are assigned more complex tasks and gain independence to develop leadership skills.

Electrical and electronics engineering technicians usually have an associate's degree or certificate from a community college or technical school. Technicians participate in on-the-job training for several months, depending on their specialty and employer, and are supervised by engineers.

Installation, maintenance, and repair occupations

Depending on the occupation, installation, maintenance, and repair workers either have formal education or train on the job.

Electrical and electronics repairers must be knowledgeable about electrical equipment and electronics. Employers often prefer to hire candidates who have an associate's degree from a community college or technical school, although a high school diploma is sufficient for some jobs. Entry-level repairers may begin by working under the guidance of experienced technicians and work independently after developing their skills.

Electrical power-line installers and repairers get most of their training on the job. Most employers require candidates to have a high school diploma or equivalent, along with basic knowledge of algebra and trigonometry and good reading and writing skills.

Line installers and repairers often must complete formal apprenticeships or other training programs. These programs, which can last up to 5 years, combine on-the-job training with technical instruction. Safety regulations define the training and educational requirements for apprentice electrical line installers, but licensure is not required.

Telecommunications equipment installers and repairers usually need postsecondary education. Many community colleges offer programs in telecommunications, electronics, or electricity. Some programs work with local companies to offer 1-year certificates that emphasize hands-on fieldwork. More advanced 2-year associate's degree programs offer courses in electricity, electronics, fiber optics, and microwave transmission.

Production occupations

Workers in these production occupations should have at least a high school diploma or equivalent, but they also may need skills and experience or other training.

Electrical and electronic equipment assemblers usually have a high school diploma or equivalent and are trained on the job for a few weeks to several months. Some employers prefer to hire assemblers who have some training or experience working with electrical or electronic equipment, either through previous employment or from training at a community college or technical school.

Powerplant workers, including distributors, dispatchers and operators, generally need a combination of education, on-the-job training, and experience. Power plant operators need strong mechanical, technical, and computer skills. Workers in jobs that could affect the power grid must have certification from the North American Electric Reliability Corporation. For highly technical jobs, workers need a strong math and science background.

Because of security concerns, many power plant operators are subject to background investigations and must not have a criminal record. They also must be willing to submit to random drug testing.

Other occupations

Training requirements vary for electricians, meter readers, and urban and regional planners.

Electricians train through supervised apprenticeships administered by technical schools and community colleges. Apprenticeships usually consist of 4 or 5 years of paid on-the-job training and at least 144 hours of related technical instruction per year. Applicants for apprenticeships must be at least 18

Powerplant workers generally need a combination of education, on-the-job training, and experience.

years old and in good physical condition. Drug tests may be required, and most apprenticeship programs ask that applicants have at least a high school diploma or equivalent.

Most states require electricians to be licensed. Licensing requirements vary, but states commonly require 2 to 5 years of experience, followed by a test of knowledge about the trade and local codes.

Meter readers usually need a high school diploma and a valid driver's license. Jobs in this occupation will be difficult to find as the smart grid is developed, however. Meter readers will need to be retrained to work in another occupation.

Urban and regional planners typically have at least a master's degree in urban or regional planning or a related field. Some urban and regional planners may earn professional certification with the appropriate combination of education and professional experience and by passing an examination.

For more information

This article describes some of the occupations related to smart grid technologies. To learn more about these and other occupations related to electric power, see the BLS *Occupational Outlook Handbook* (*OOH*), **www.bls.gov/ooh**. The *OOH* describes hundreds of occupations in dozens of industries and includes details about employment, wages, education and training requirements, and job outlook.

The BLS Occupational Employment Statistics (OES) program provides employment and wage data for occupations nationally and by industry and geographic location. Additionally, you can create customized tables by industry and geographic area. See the OES occupation profiles at **www.bls.gov/oes/current/oes_stru.htm**.

In addition to this article, BLS has published other information about green careers. See **www.bls.gov/green/greencareers.htm**.

Preparing for smart grid jobs may require additional training for workers in existing occupations. The *Occupational Outlook Quarterly* (*OOQ*) has published a number of recent articles on topics related to education and training, including:

- "Apprenticeship: Earn while you learn," **www.bls.gov/ooq/2013/summer/art01.pdf**
- "Certificates: A fast track to careers," **www.bls.gov/ooq/2012/winter/art01.pdf**
- "High wages after high school—without a bachelor's degree," **www.bls.gov/ooq/2012/summer/art03.pdf**
- "Paving the occupational path: A new system for assigning education and training," **www.bls.gov/ooq/2011/fall/art02.pdf**

To find Energy Department-sponsored training programs related to all levels of smart grid development, visit the Smart Grid Information Clearinghouse at **www.sgiclearinghouse.org/education**. In addition to information about degree and nondegree programs, the clearinghouse offers links to short courses, webinars, and tutorials from other providers.

For general information about the smart grid, including government-sponsored smart grid projects, visit the U.S. Department of Energy site **www.smartgrid.gov**.