Women in Power

Electricity truly changed the world! It transformed all-day chores in homes and on farms into automated tasks. This gave more people, especially women, the chance to attend college and enter the workforce.

> *"Is it a fact—or have I dreamt it—that, by means of electricity, the world of matter has become a great nerve, vibrating thousands of miles in a breathless point of time."*
>
> Nathaniel Hawthorne
> Author (1804–1864)
> from *The House of the Seven Gables*

Electricity also fueled an industrial economy beginning at the turn of the 20th century, when manufacturing plants—powered by electricity—started to mass-produce products.

It's easy to take electricity for granted. Just flick a switch, and on go the lights! In reality, electricity is the work of thousands of engineers who design machines to harness energy from coal, natural gas, oil, and radioactive materials. Other engineers develop networks to deliver the electricity from power plants to our homes, businesses, and industries.

Above: Solar power towers, Albuquerque, New Mexico.

Right: Generators.

The ever-increasing demand for electricity means that engineers must find ways to avoid black-outs and keep cities humming. Other engineers are dedicated to generating and distributing energy more efficiently, without harming the environment.

Awesome Output

Isn't it amazing that when you stick a plug into an outlet, you get electricity? Where does that electricity come from, though? There are three main steps: generation, transmission, and distribution.

Electricity is generated at a power plant. A "turbine" (a wheel, blades, or fan) turns a shaft with a large magnet attached to it. The shaft and magnet are inside a coil of wire. As the magnet passes over the wire, it generates an electric current. The wire and magnet are called "generators."

The electricity is carried—or transmitted—through large high-voltage lines, sometimes over long distances. The electricity is then distributed to low- and medium-voltage users—that's us!

The first machines to generate electricity were developed in the 1880s. But there was plenty of room for improvement! Women engineers were instrumental in developing bigger, better, and more efficient power generators and turbines.

"Knowledge is power."

Sir Francis Bacon

Philosopher, Politician, and Author

(1561–1626)

Although we don't know for sure, Bertha Feicht most likely assisted her husband and brother behind the scenes in developing the Niagara Falls power plant, completed in 1895. The plant was a marvel in its day because it harnessed the power of the Niagara River (right) and provided power to the city of Buffalo, New York, some 22 miles away.

Background: Turbines.

Voice of Influence

As a child, mechanical engineer **BERTHA LAMME FEICHT** (1869–1943) and her brother, Benjamin, made their own toys and talked about starting their own toy company some day. The two did wind up at the same company, Westinghouse, where they worked with motors and generators—much larger "toys!"

Bertha attended engineering school to satisfy her curiosity about the way things worked. In 1893, she joined Westinghouse, where her brother had already become chief engineer. She and Benjamin worked in a design group that did early research in transmitting electricity. Bertha's future husband, engineer Russell Feicht, joined the group. But once he and Bertha married, company rules stated they could not work together.

Bertha retired in 1905. Many suspect she didn't stop working in engineering, though. She may have helped her brother and husband with their projects for Westinghouse. If so, she was a powerful influence!

To honor Bertha as the first women engineer at Westinghouse, the Westinghouse Educational Foundation, in conjunction with the Society of Women Engineers, established a scholarship in her name in 1973. The Westinghouse/Bertha Lamme Scholarship is awarded each year to a female college freshman studying electrical engineering.

Bertha Feicht's interest in math and her brother's love of his own engineering career enticed her to study engineering. Bertha is pictured here, around 1893, during her student days at Ohio State University.

Emma Barth helped Westinghouse customers buy the right power plant equipment to meet their needs. Here, she compares a manufactured turbine to the blueprints—plans and drawings—for the turbine.

In The Dark

Mechanical engineer **EMMA BARTH** (1912–1995) spent 33 years designing turbines and generators for Westinghouse. Specifically, she reviewed the needs of people buying her company's power plant equipment to make sure their purchases were a perfect match.

There was only one problem. Since many power plant managers would not allow women inside the plants, Emma could not see how the machinery, once installed, was working.

If someone reported a problem, a male engineer went to the plant, took photographs of the equipment, and described his observations to Emma so she could solve the problem. Imagine how difficult that was!

A few times, friends took her on plant tours. Or if her entire department went to a plant for a demonstration or photo, she could go, too. Emma would appreciate that, today, there are no such restrictions for women engineers.

Electric Expert

Electrical engineer **FLORENCE FOGLER BUCKLAND** (1898–1967) wielded great influence on steam turbines and other devices made by General Electric. Florence went to work at General Electric in 1921, straight out of college. She performed calculations to find ways to increase the power output in steam turbines.

Florence later became a heat transfer expert for General Electric. Other engineers sought her advice for improving everything from irons and kitchen ranges to locomotives and giant turbines. She had a knack for thinking of better ways to cool a motor or make a heating element smaller and lighter.

Florence also helped future generations of engineers by writing engineering reference books used by General Electric staff.

Above: The General Electric Company, Schenectady Works, 1907, where Florence Buckland worked.

Left: Florence (third from the left) worked for General Electric a few years, then went back to college. She earned a Master's degree in Electrical Engineering from Union College in 1925. Florence returned to General Electric and worked there until the 1960s, with a 16-year hiatus to raise her two children.

Hot Career in Heat

When mechanical engineer **NANCY DELOYE FITZROY** (b.1927) asked her father for a record player, he gave her one—unassembled. "My parents recognized my brain needed exercise," she says. With patience and care, Nancy built that record player. Later, she studied engineering to learn how more things worked.

NANCY FITZROY was the first woman president (1986–1987) of the American Society of Mechanical Engineers.

After graduation, Nancy became a heat flow expert at General Electric. She wrote a book on the subject and delved into heat principles' many practical applications.

"I worked on everything from toasters and television tubes to submarines and satellites," she says. She designed better cooling systems for equipment, such as space satellites and aircraft jet engine afterburners. Nancy then created computer simulations to verify their higher operating efficiencies.

Although women engineers were rare early in Nancy's career, she says male engineers treated her well because they respected her work. Her husband of 53 years, and fellow engineer, Roland V. Fitzroy, Jr., was her mentor.

Besides working for General Electric, Nancy Fitzroy found time to fly her twin-engine airplane, *Nancy's Fancy*, and helicopters, too.

In Control

Power plant operators need to run their plants safely, reliably, and economically. To do that, careful monitoring, control, and coordination is required for all the plant's equipment: boilers, turbines, generators, and other machinery.

The flow of electricity from the plant must also be regulated. Additional instruments monitor power generation processes to be sure no problems, such as cooling water releases, damage the environment.

As power plants have grown in complexity, controls and instrumentation have become critical for proper plant operations. Mechanical engineer and control systems engineer **ADA I. PRESSMAN** (1927–2003) was an expert in power plant controls.

Working at Bechtel Corporation for most of her career, she saw control systems evolve from manual switches to complex automated systems. Ada was responsible for many breakthroughs leading to the development of these more precise and reliable sensors and controls.

During her career with Bechtel Engineers Power Division in Los Angeles, Ada Pressman managed 18 design teams for over 20 power plants, both nuclear and fossil fuel plants, throughout the world.

Among Ada Pressman's great achievements was the engineering of control systems for the San Onofre Nuclear Generating Station, which provides enough power to serve 2.75 million households in Southern California.

Americans use the equivalent output of five power plants every year to power electronics while they're turned off. So unplug while not in use!

The Juice Behind the Power

Most power plants in the United States use steam made in large boilers to drive the turbines. But what heats up the boiler to create steam?

Usually the heat comes from burning fossil fuels, such as coal, natural gas, and oil. Nuclear power plants use controlled nuclear reactions instead. In some parts of the country, steam comes directly from geothermal fields—places in the earth where water is heated naturally underground.

The fuel used depends on a region's available resources. For just over half of U.S. residents, that fuel is coal. Nuclear energy and natural gas each serve about one-fifth of the U.S. population. Hydroelectric power, generated at dams along large rivers and lakes, provides a small percentage of the country's power. Power plants fueled by oil and geothermal energy from natural steam fields round out the list.

Nicely Nuclear: Fission and Fusion

Nuclear power may sound mysterious. But it's just another way of making steam for power plants. So how does it work?

The key is nuclear fission. Think of a "fissure" as a "crack" or "split." Nuclear fission splits atoms to release heat. In a nuclear reactor, atoms of a nuclear fuel, usually uranium, are split to release heat. The heat powers boilers to make steam.

The opposite of nuclear fission is nuclear fusion. That's how the sun and stars get their energy. "Fusing" means "to combine." By combining atoms, mass is increased, which increases energy.

New Nukes

Nuclear engineer **KATHRYN A. MCCARTHY** (b.1961), a manager at the Idaho National Laboratory, is looking for new ways to harness nuclear power for energy.

Kathryn's area of expertise is nuclear fusion, and she has worked with a global team of experts to design a large-scale fusion reactor, the International Thermonuclear Experimental Reactor (ITER).

"My job was helping to prove the reactor would operate safely," says Kathryn. Construction on the ITER is expected to start soon.

Kathryn finds her natural empathy wins trust and eases the public's concerns about nuclear power. "Woman can have a big impact in this field," she says.

Above: As a manager at a top research facility, Kathryn McCarthy oversees work on both nuclear fission and nuclear fusion projects.

Right: The nuclear engineer describes her work as challenging and fun. She takes a lunchtime run every day to feel energized for busy afternoons.

Coal? Cool!

When electrical engineer **JILL S. TIETJEN** (b.1954) talks, people listen. She travels nationwide to give expert testimony on a number of power plant issues—from fuel costs to energy resources.

For example, Jill testified before Wyoming officials that two coal-fired power plants should be authorized for construction in Wyoming, home to many coal reserves. One, an 85-megawatt plant, now serves northeastern Wyoming communities, and construction started on the second plant in 2005.

"Electric utilities seek my opinion when they want to build a new power plant," says Jill. She has worked primarily with coal-fired plants, but understands other sources of energy, too. Jill helps utilities plan new investments. She develops detailed plans showing how a new power plant will work in concert with existing plants.

"I suggest ways the plant can operate as economically as possible and determine how much fuel it will require," she says. "When I look out from an airplane and see the lights on below, it gives me great pride to know that I help people have electricity to power their lives."

In addition to offering expert power plant advice, Jill Tietjen gives motivational speeches nationwide. She also co-authored the book, *Keys to Engineering Success* and *Setting the Record Straight: The History and Evolution of Women's Professional Achievement in Engineering*.

Invisible Energy: Natural Gas

Workers at the Katy Gas Plant near Houston, Texas, had never seen a woman at their facility until chemical engineer **CYNTHIA OLIVER COLEMAN** (b.1949) reported to work. "And it was the first time I'd been at a gas plant, too," she says.

Like most engineers, Cynthia had developed strong problem-solving skills in college. But she would learn much on the job. In a short time, she became an expert in natural gas plant operations.

Later, Cynthia became an "energy detective." She surveyed natural gas fields and used computer programs to determine how much natural gas the field might yield and how to recover the most fuel possible.

As the first African-American woman chemical engineering graduate from the University of Houston, Cynthia felt honored to share her story here. "I carried out my mission to encourage others—especially minorities—to study engineering," she says.

Cynthia Coleman spent her entire 32-year career with ExxonMobil so she could remain in Houston with her family. Her daughter is now a medical doctor in Houston.

Power to the People

Electricity is still not commonplace in some Asian, African, and South American countries. But people in the United States and other developed nations worldwide can thank the engineers who pioneered transmission systems every time they flip a light switch or power on a computer.

Women engineers were involved in early power transmission systems. Today, they work for utility companies as design engineers and managers, making sure power is always available for our increasingly electronic world.

Bringing electricity to farms meant that tasks could be automated. With fewer hands needed, children raised on farms could pursue higher education.

Rural Voltage

Electricity became commonplace starting in the 1890s. In cities, that is. Although nearly 90 percent of urban dwellers had electricity by the 1930s, only ten percent of rural residents did.

The Rural Electric Administration, established in 1935, took on the job of bringing electricity to outlying parts of the country. Power transmission and distribution grids further expanded to provide inexpensive electric lighting and power to farms.

Electrical engineer **HILDA COUNTS EDGECOMB** (1893–1989) helped the Rural Electric Administration in its efforts to bring electricity to America's farmers. She reviewed engineering plans for transmission lines and substations and made sure the facilities designed would meet their goal of delivering power to remote areas.

By simplifying power transmission calculations, Edith Clarke reduced the need for hand calculations, typically performed by women, and opened up the once male-dominated electrical engineering field.

Human Calculator

A hundred years ago, an orphaned girl was encouraged to save her inheritance. Electrical engineer **EDITH CLARKE** (1883–1959) went against this advice by spending her nest egg on a college education. She studied math and astronomy so she could have interesting work.

Edith taught math and then became a "calculator" for American Telephone and Telegraph (AT&T) in 1912. In the early 20th century, the only calculators were the human kind. People were hired to do the mathematical calculations needed to design electrical equipment.

At AT&T, Edith learned about engineering, then went back to college for an electrical engineering degree. After graduating, however, no one would hire her as an engineer. She was told that women were only suited to be "calculators," or "computors," as they were also called.

When General Electric finally gave her an engineering job, her assignment was to find ways to transmit electricity over great distances with as little loss of energy as possible.

Edith developed transmission line charts that simplified the calculations and reduced the time needed to solve problems in design and operation of electrical power systems. Edith also patented a method to regulate voltage on power transmission lines so the lines could operate near maximum power limits and provide electricity to more people.

Bright Lights, Big City

Over 3,000 miles of distribution circuits serve Seattle City Light's 380,000-plus customers. As director of central electrical services, electrical engineer **ELISABETH "BETTY" A. TOBIN**, makes sure the power is always on in downtown Seattle's underground network.

Betty was the first woman electrical engineer hired by Seattle City Light. She worked in several departments including a stint designing substations and facilities to generate and transmit electricity. "I liked doing all aspects of the work, not specializing, so I learned a lot," she says.

Now in an engineering management position, Betty takes a "big picture" outlook encompassing political, legal, and personnel issues. "I enjoy advocating for my employees, and getting them what they need to do their jobs well," she says. She keeps her design skills sharp through active involvement in IEEE, an electrical engineering society.

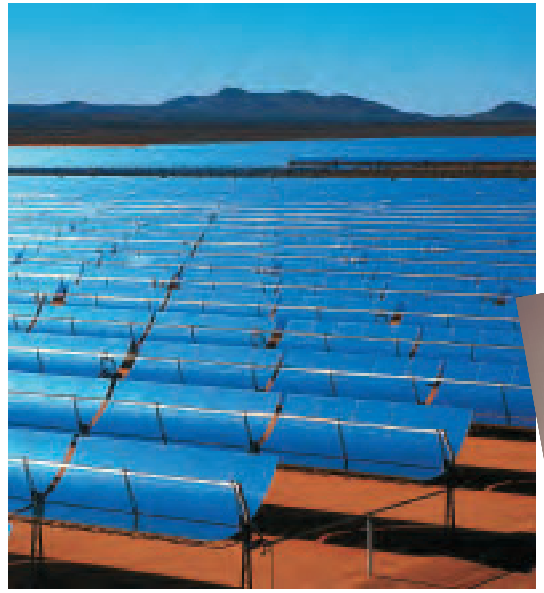
Betty Tobin credits her engineering background with making the move into utility management possible. "The type of job I do is not something you can just fall into without qualifications," she says.

Lessening the Impact

Meeting the public's need for power is not the only concern for power companies. Utilities must be sensitive to the impact that power plant operations may have on the local environment and to unique regional needs.

Women engineers working in power help preserve habitats, the places where native plants and animals, including endangered species, live. Others teach utility customers how to conserve energy to stretch limited energy reserves and reduce the need to generate power.

To move away from the use of fossil fuels, women engineers are working in the public and private sector to generate energy from clean, eternally-renewable sources: the sun, wind, and water.



Solar thermal systems can provide electrical power for industrial, commercial, and residential customers. Solar power is a sustainable, environmentally-friendly option, but its higher operating costs, compared with traditional energy sources, must also be considered when evaluating energy alternatives.

Habitat Enhancements

In one of her first jobs for a power plant near the Atlantic coast, industrial engineer **TERESA A. HELMLINGER** (b.1953) designed a slide to help tiny shrimp and other marine life return to the ecosystem rather than get pulled into a pump drawing water for the plant. Her inspiration for the low-friction device? Fiberglass swimming pool slides!

In another project, Terri and her team delivered power to an uninhabited island so the marines at a nearby military base could do training exercises. "The only catch was that part of the island was the habitat of an endangered woodpecker," says Terri. While most of the power lines were buried underground, Teresa and her team used overhead power lines through the habitat. "That way, the woodpeckers had new, tall power poles for perching," she says.

Terri advanced to managerial roles with Carolina Power & Light. She and project teams found ways to save money and increase revenues for the utility.

In 2003, **TERESA HELMLINGER** became the first woman president of the National Society of Professional Engineers.

After a career with Carolina Power & Light, Terri Helmlinger became the director of a North Carolina State University group offering technical assistance to state businesses and industries.

Green Goals

The term "sustainability" refers to a way of life in which economies, people, and nature flourish. The word was not used in engineering school when mechanical engineer **JANICE PETERSON** (b.1950) got her degree. Now, her work is all about sustainability. And she loves it!

She meets with Portland General Electric's business customers in their workplaces to suggest ways to use less electricity. "I'm constantly away from the office," says Janice. "But that's OK!"

Janice offers a complete, resource-saving package by advising business owners in water use, waste disposal, and ways to minimize trash going to landfills as well. For companies that want to build an energy-efficient building from the ground up, Janice works with building owners, architects, and construction contractors during the design and building stages.

Janice Peterson likes being in the field, meeting people, and seeing places the public rarely gets to go—data centers, mechanical rooms, rooftops. "I get a behind-the-scenes look at a lot of companies," she says.

Southwestern Sun

Just a few years ago, the Navajo Nation in parts of Arizona, New Mexico, Utah, and Colorado lived too far from established power grids to get electricity in their homes. "Bringing the energy to them would have cost $27,000 per mile, far more than tribe members could afford," says Native American civil engineer **SANDRA K. BEGAY-CAMPBELL** (b.1963). "Many lived over 10 miles from the grid!"

Sandra helped the Navajo Tribal Utility Authority place solar units on individual homes to generate electricity. The cost for homeowners is $75 a month. A much better deal!

Sandra has helped hundreds of tribe members get electricity. "I'm the helpful hand that comes with federal funding," Sandra says, referring to a Department of Energy Tribal Energy Program in which grant recipients receive her technical assistance as part of a package.

In addition to solar energy, Sandra looks into other alternative energy sources such as wind power, geothermal power, and biomass (trash and industrial wastes burned for energy).

At left, Sandra Begay-Campbell poses with a solar car. Above, she stands in front of a solar system providing power on one of her projects.

She proudly passes on the engineering tradition by mentoring teens. In addition, three of her cousins are studying to be engineers, and a niece now in high school plans to join the profession, too!

"I get to work with my own native people. I give them a new way to think about having electricity. It's very nurturing."

—Sandra Begay-Campbell