Approved: March 24, 2009
Date

MINUTES OF THE HOUSE ENERGY AND UTILITIES COMMITTEE

The meeting was called to order by Chairman Carl Holmes at 8:00 a.m. on March 6, 2009, in LAWRENCE, KS.

All members were present except:
Representative Carl Holmes- excused
Representative Dan Johnson- excused
Representative Forrest Knox- excused
Representative Annie Kuether- excused
Representative Margaret Long- excused
Representative Don Myers- excused
Representative Cindy Neighbor- excused
Representative Rob Olson- excused
Representative Josh Svaty-excused

Committee staff present:
Melissa Doeblin, Office of the Revisor of Statutes
Sean Ostrow, Office of the Revisor of Statutes
Mary Galligan, Kansas Legislative Research Department
Cindy Lash, Kansas Legislative Research Department
Renae Hansen, Committee Assistant

Conferees appearing before the Committee:
Westar Energy
Bowersock Energy

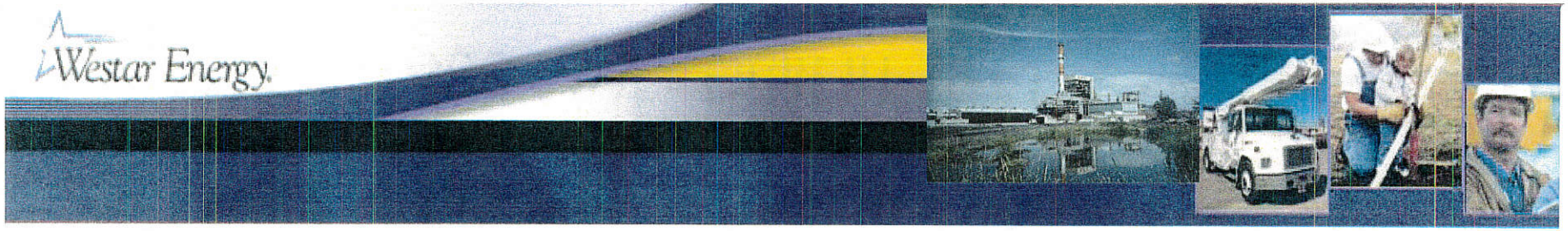
The committee traveled to Lawrence Kansas for a tour of both the Lawrence Energy Center and Bowersock Energy.

Westar presented a power point, (Attachment 1) about their plant. Mark Schreiber handed out a Lawrence Energy Center fact sheet (Attachment 2). Additionally those in attendance were treated to a complete tour of the plant.

At Bowersock Energy the committee heard about the extensive history of the plant from Stephen Hill and an explanation of how the plant works. Additionally, the committee was able to tour the facility in its entirety. Three brochures were handed out to the tour members: Renewable Energy and Hydropower, (Attachment 3), The Bowersock Mills and Power Company, (Attachment 4), and Electricity: What is it? Where does it come from? How does it work? (Attachment 5).

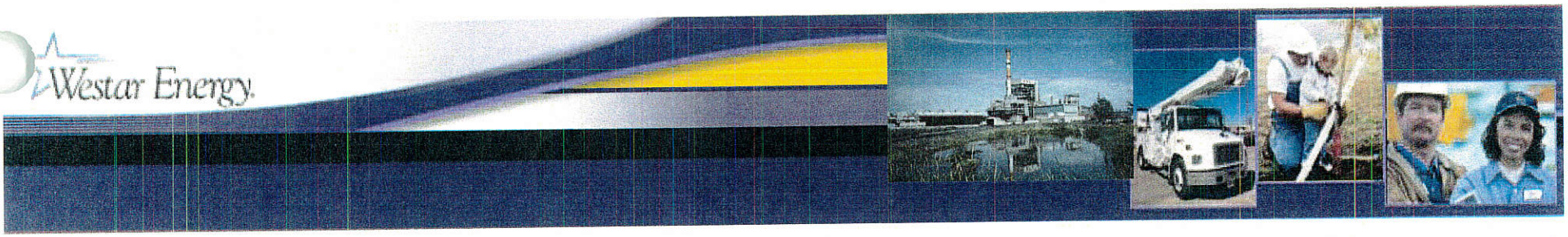
The next meeting is scheduled for March 10, 2009.

The meeting was adjourned at 12:00 p.m.



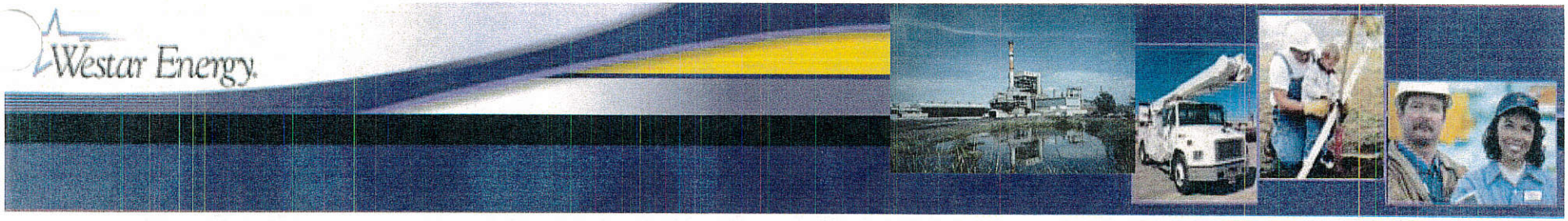
Westar Energy
Lawrence Energy Center

March 6, 2009



Lawrence Energy Center

- 576 MW Base Load PRB Coal Facility
- 117 Employees
- Unit 1 on-line in 1938; Unit 1 & 2 retired
- Unit 3 – 56 MW – Built in 1955
- Unit 4 – 117 MW – Built in 1960
- Unit 5 – 403 MW - Built in 1971



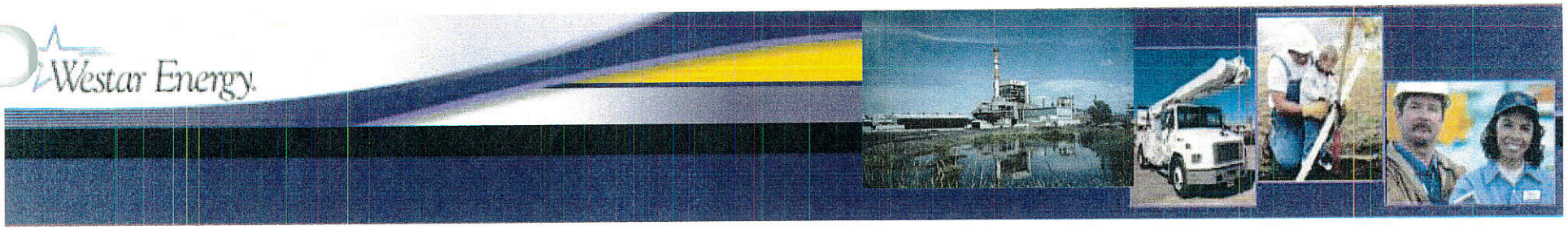
Lawrence Energy Center

- 2007 PRB Coal Users Group Plant of the Year
  - Recognized for quality conversion to burning Powder River Basin fuel
    - Safety
    - Cleanliness
    - Hazard Mitigation

Westar Energy

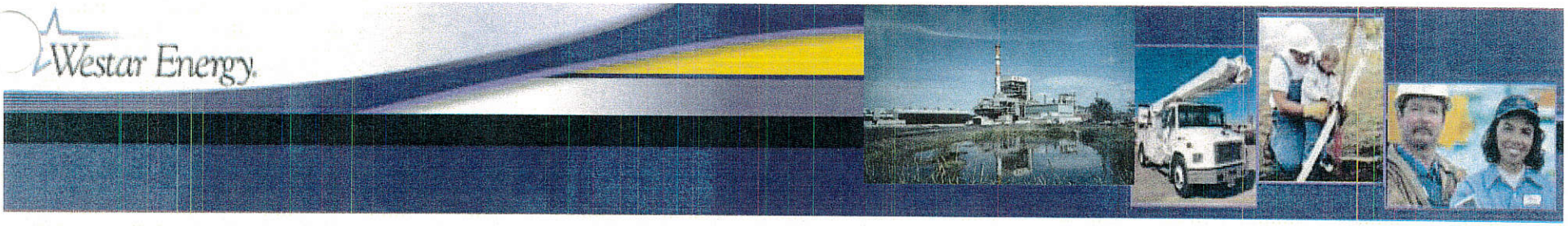
Lawrence Energy Center

- Pollution Control Equipment
  - L5 Low NOx burners
  - L4 & L5 wet flue gas scrubbers
  - L3 electrostatic precipitator



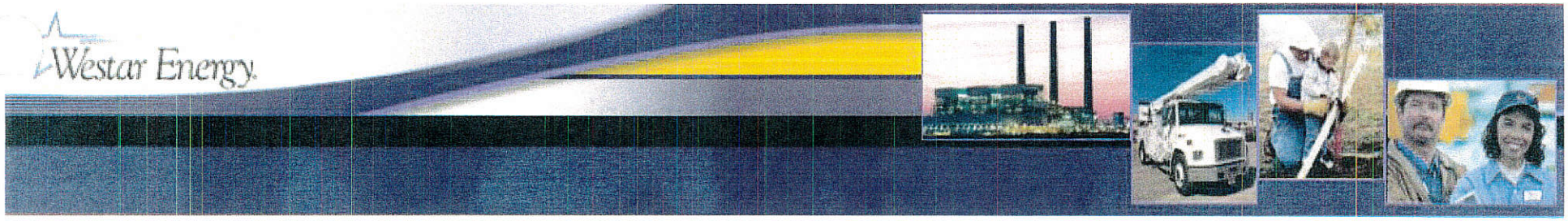
L5 Low NOx Burners

- World's first Pollution Minimum Low NOx burner system was installed as a retro-fit on Unit 5 in 1987. This burner arrangement along with the addition of overfire air allows for a reduction of nitrogen oxide (NOx) from the flue gasses by providing more efficient mixing of fuel and air.
  - ✦Joint project with Westar, Combustion Engineering and Electric Power Research Institute.



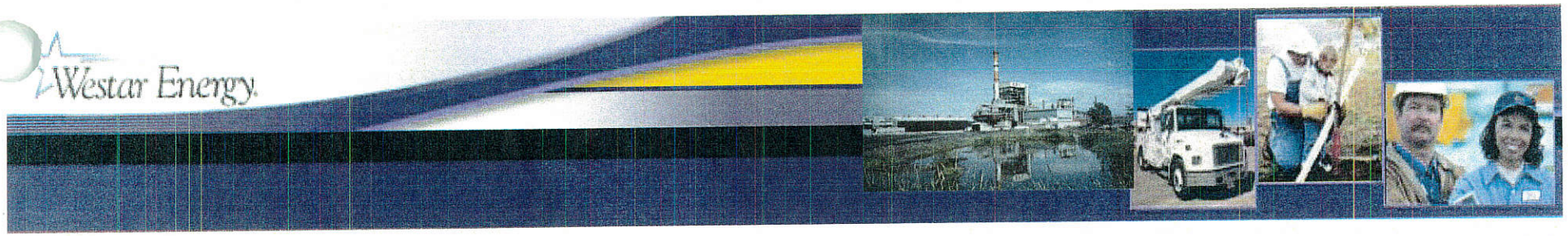
Scrubbers

- L5 was installed with the first original equipment limestone injection wet scrubber in the United States on a fossil fuel steam electric generating unit. (1971)
- L4 was the first unit to be retrofitted with a limestone injection wet scrubber in the United States. (1968)



Future Environmental Upgrades

- L5 – Spring 2012
  - Baghouse installation for particulate removal
  - Scrubber enhancements to improve SO2 removal
  - Enhancements to improve low NOx burner performance
- L4 – Fall 2012
  - Baghouse installation for particulate removal
  - Scrubber enhancements to improve SO2 removal
  - Low NOx burners
- L3 – Spring 2013
  - Precipitator upgrade to enhance particulate removal
  - Low NOx burners

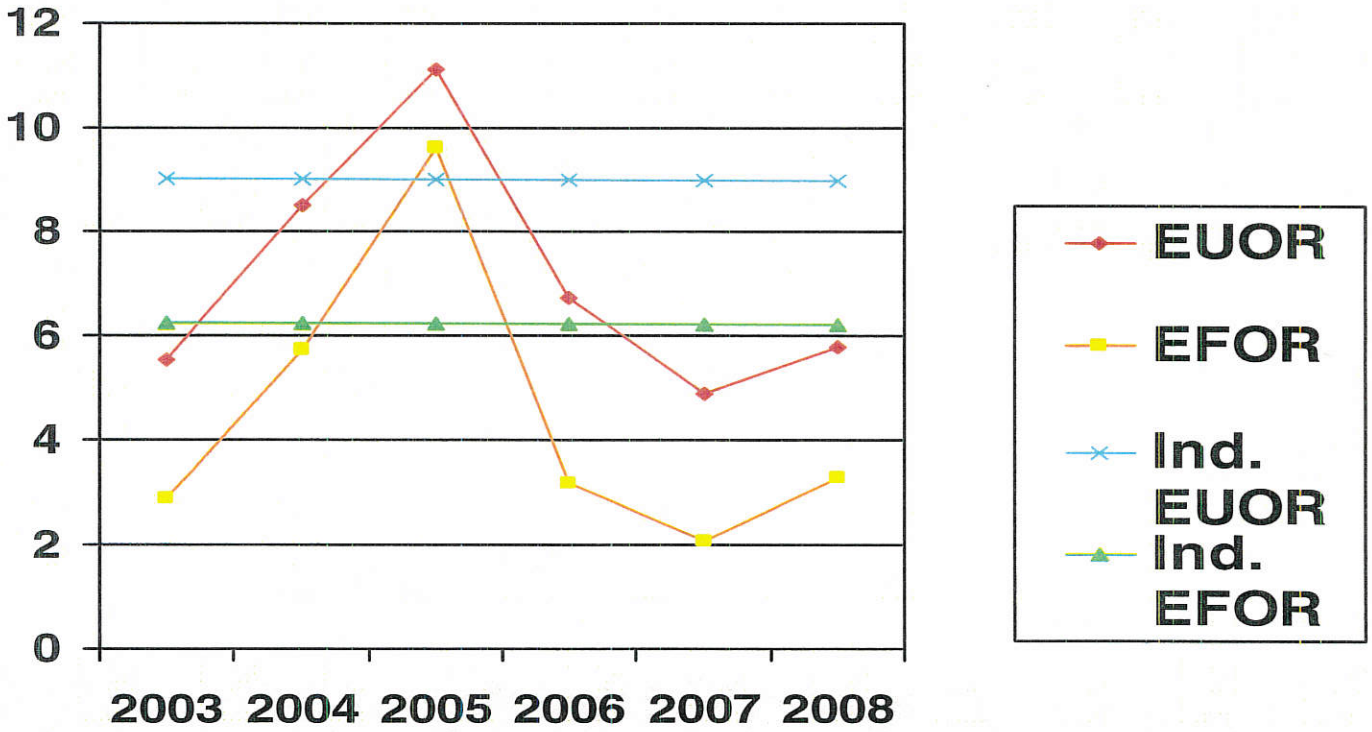


2008 Milestones

- Net Generation – 3,781,000 MW-HRS
  - Record for Annual Net Generation
- 2,356,220 Tons Of Coal Burned
  - 21,420 Rail Cars Unloaded
- OSHA Recordable Incident Rate – 0.83
- EUOR – 5.8%, Equivalent Unplanned Outage Rate
- EFOR – 3.3%, Equivalent Forced Outage Rate

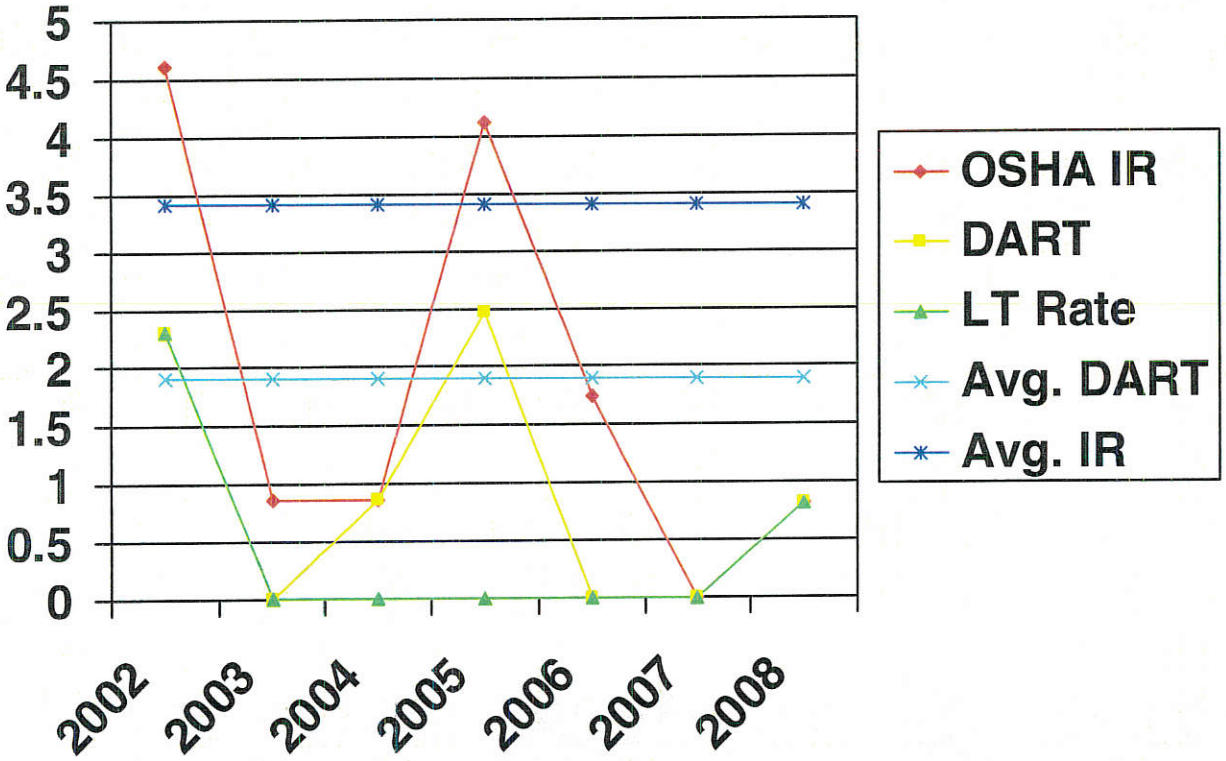
Westar Energy

Reliability Trend



Westar Energy

Safety Trend



Westar Energy

Safety, How do you do it?

- Hourly Safety Specialist
- Loss Prevention Program with audits
- Safety Observation System (SOS) for management employees
- Peer to Peer observation program for hourly employees
- Culture survey and follow-up actions
- Benchmarking
- Joint Safety Advisory Committee = management and union leaders working together
- Plant Safety Task Force
- "Be the Best" attitude among management and hourly staff. Strong leadership at all levels

Westar Energy.

Westar Energy®

STATISTICS AS OF JANUARY 2009

COMPANY OVERVIEW

Headquartered in Topeka, employs about 2,200 people.
Serves more than 675,000 customers in much of the eastern third of Kansas.
Thirteen energy centers with more than 6,800 megawatts of capacity.
Three wind farms with 300 megawatts of capacity.
Operates 33,000 miles of transmission & distribution lines.
Approximately 10,828 shareholders in Kansas.
Westar Energy's rates are approximately 25% below the national average.

LAWRENCE AREA FACT SHEET

EMPLOYEES / RETIREES

Number of employees in Douglas County	175
Annual payroll	$11,508,458
Number of retirees in Douglas County	75

CUSTOMERS

Residential customers	43,522
Commercial customers	5,256
Industrial customers	45

COMMUNITY SERVICE

Number of volunteered hours by employees & retirees	5,561
Employee and corporate United Way Gift	$17,947

FINANCIAL BASE

Property Tax	$5,664,001
Sales Tax	$1,880,999
Franchise Fee	$3,424,630

www.westarenergy.c

HOUSE ENERGY AND UTILITIES
DATE: 3/6/2009
ATTACHMENT 2

What is energy and why do we need it?

Energy is the capacity for action or accomplishment (the ability to do work). While much of the energy people use is generated by the human body, many of our actions and accomplishments require additional energy that must be generated from an outside source, such as steam, water, wind, or a fuel such as gasoline. Driving a vehicle, turning on a computer, grilling on the barbecue, and turning on a light all require additional energy.

Where does energy come from?

In a very broad sense, all of the world's energy comes from the sun. Solar energy radiates through space and strikes the earth, warming it, creating weather patterns, and causing plants to grow. This solar energy is then stored in the form of heat, the kinetic energy (energy of motion) of storms, or the chemical energy stored in plants as they grow through photosynthesis. As an example, the gasoline used in cars is derived from plant matter that has been buried in the earth for millions of years (fossil fuels).

What are the problems with energy production?

The United States is currently dependent upon sources of energy that are in short supply and/or pollute the environment. Electrical energy in the United States is produced primarily from coal-fired generators and nuclear power plants. The supply of coal, although large, is limited and generation of power from coal-fired and nuclear power plants both pose significant environmental hazards.

Environmental Issues

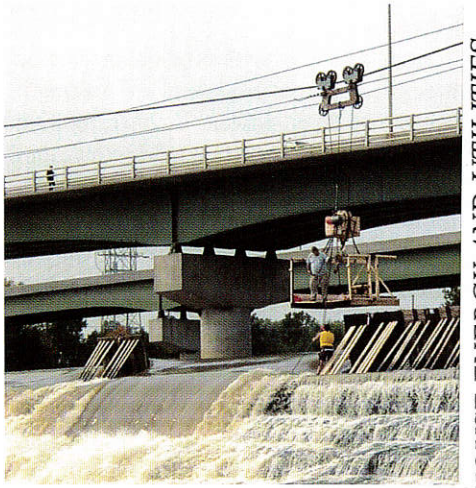
Most electical energy in the US is produced by coal-fired generators (56%) and nuclear power (23%). Both energy sources present significant problems for the environment. Coal has been the fuel of choice for many decades because it has been plentiful and inexpensive. A coal plant burns about 1 lb. of coal to produce 1 kWh of electrical energy. This consumes about 10 lbs. of air and produces 2 to 3 lbs. of carbon dioxide (CO_2). According to current theory, the increase of CO_2 in the atmosphere is responsible for **global warming.** Scientists are concerned that if global warming continues, humans may face hazardous climatic changes.

Scientists have also discovered that coal-fired energy production is a primary contributor to **acid rain**, which is when acid falls out of the atmosphere in the form of rain, fog, or snow. In the U.S., about 2/3 of all SO_2 and 1/4 of all NO_x comes from electric power generation that relies on burning fossil fuels, such as coal. These compounds react in our atmosphere and fall back to earth in the form of dilute solutions of nitric and sulfuric acids. These have a variety of effects, including damage to forests and soils, fish and other living things, materials, and human health. Burning of coal also contributes to **particulate air pollution**. Some public health experts have come to view particulates as one of the most serious air pollution problems associated with electricity generation, aggravating asthma and other respiratory conditions. Nuclear power also presents a host of problems including where to dispose of radioactive wastes.

Energy use in the United States

Although it has only 5% of the world's population, the US consumes 25% of the world's energy production. Energy use in the U.S. is increasing in spite of advancements made in energy saving technologies. According to the US Department of Energy, per person energy consumption in the United States has increased 8.9% in the last 30 years and is expected to increase by over 40% in the next twenty years. For this reason, people are working to develop new sources of energy, as well as to enhance existing forms of sustainable energy production.

The Montezuma Wind Farm, near Dodge City, is Kansas' first. The Great Plains is called the Saudi Arabia of Wind Energy, and Kansas has the highest potential of all states for the production of wind energy when infrastructure is considered.



HOUSE ENERGY AND UTILITIES
DATE: 3/6/2009
ATTACHMENT 3-1

The Bowersock Dam requires constant maintenance. Pictured is a workman replacing a portion of the temporary wooden dam that is designed to break away during high water. This is a safety feature to prevent the water from rising too high and flooding upstream properties.

Green Power

Some forms of electrical generation, called renewable energy (green power) do not increase carbon dioxide emissions, do not produce toxic waste, and are replenished naturally. One of the greatest advantages to green power is that THE FUEL IS FREE. Even though there may be a slightly higher initial cost, in 10 or 20 years the fuel will still be free. Who knows what the price of coal or petroleum will be? It probably will not be cheaper. Green power includes wind, solar, geothermal, oceanic, biomass, and most hydroelectric power. To learn more about these technologies see **www.pinnaclet.com/reusable/index.html**

Why not use all green power?

The United States uses far more energy than could be produced by green power alone. Currently only 11% of the U.S. energy supply comes from renewable (or green) sources, mostly hydropower. Yet, with some effort a significantly larger portion of our energy needs could be met with green power. As an example, mountainous states with adequate precipitation are ideal for hydropower facilities. In the Pacific Northwest, up to 70% of electricity is generated from hydropower. States must make efforts to make the production of green power more feasible in order to increase its use. Currently less than 1% of the electricity used in Kansas is provided by renewable resources (EIA 1998).

Green Power in Kansas

Use of renewable energy is increasing throughout the United States. At least three green power producers are making it possible for Kansans to use green power. In 2001, the first commercial Kansas wind farm was completed southwest of Dodge City. The 110 megawatt farm is a project of FPL Energy. The 165 turbines will produce enough electricity for 27,500 homes. Westar Energy has established a wind power project known as Westar Wind, which allows Kansas customers to buy wind-generated electric power from the company's first two commercially operated wind turbines which were built at the Jeffrey Energy Center, near St. Marys, Kansas. The Westar wind turbines produce approximately 2.9 million kWh of electricity annually.

In Lawrence, The Bowersock Mills & Power Company produces renewable hydroelectric power, which does not contribute to global warming, acid rain, or particulate pollution. In fact, by using hydropower instead of fossil fuels to create electricity, Bowersock substantially reduces the amount of pollutants in our air and keeps the state of Kansas cleaner and healthier for everyone.

Built in 1874, Bowersock is the only functioning hydropower plant in Kansas, but a 1993 study by the Idaho National Engineering Laboratory for DOE identified an additional 17 Kansas sites for potential hydropower production (13 on the Kaw River, 3 on the Grand-Neosho, and 1 each on the Osage and Arkansas). Development of all these resources would yield an additional 83 megawatts of electricity, or 1% of the state's generation capacity. Producing hydropower at these new facilities could be cost prohibitive due to initial capital outlay versus the amount of energy generated, but in Lawrence the structure is already in place. Bowersock currently has a capacity of 2.5 MW; production could potentially be doubled by upgrading existing facilities.

BE PROACTIVE
Tell your
Senator and Representative
"I Support
Renewable Energy"
http://da.state.ks.us/phonebook
785-296-2391

3-2

Green Power Challenges

Electricity produced with renewable technologies is cleaner and friendlier to our health and the environment than producing electricity through coal-fired or nuclear power plants. It is also slightly more expensive. Many people who feel that renewable energy is the most sensible alternative for our energy needs have enrolled in **green pricing** programs. To encourage the adoption of renewable technologies some progressive utilities offer to let consumers *voluntarily* pay a small premium for a portion of their electricity needs provided it comes from renewable sources. This allows environmentally conscious individuals to encourage the development of environmentally friendly energy sources until such time that they can compete on an equal basis. **Green pricing** would add about $0.01-$0.04 per kWh to an average energy bill. However, to control their power expenditures, individuals are allowed to limit how many "green" kWh they are willing to purchase each month. Contact your electric utility for availability, or see the following web site: **www.eren.doe.gov/greenpower/summary.shtml.**

By using hydropower instead of fossil fuels to create electricity, The Bowersock Mills & Power Co. substantially reduces the amount of pollutants in our air and keeps the state of Kansas cleaner and healthier for everyone.

SOME BENEFITS OF RENEWABLE ENERGY

- Does not contribute to *global warming*
- Improves air quality
- Improves water quality by reducing *acid rain*
- Prevents forest destruction by reducing *acid rain*
- Improves the *energy security* of our country
- Will never run out—It's renewable
- Provides *jobs* in an exciting new industry
- Adds income to rural economies
- Stabilizes the cost of energy, fuel costs will not rise

Disclaimer: This material was prepared with the support of the U.S. Department of Energy (DOE) Grant No. DE-FG48-97R802102. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of DOE.

RENEWABLE ENERGY AND HYDROPOWER

The Bowersock Reservoir on the Kansas River preserves a refuge for wildlife and provides a recreation site, drinking water and clean renewable energy for the Lawrence community.

The Bowersock Mills & Power Company

has been producing electricity in Lawrence since 1887 and is a leading proponent of renewable energy within the state.

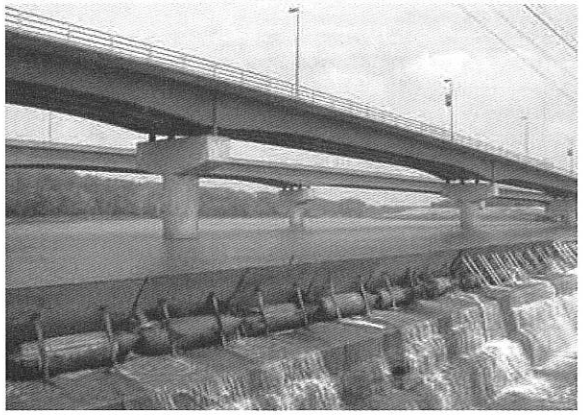
P.O. Box 66
Lawrence, Kansas, 66044
Tel: 785-843-1385
E-mail: staff@bowersockpower.com
Web Site: www.bowersockpower.com

Electricity from Water

Hydropower is the most developed renewable energy technology and is becoming more important as our need for energy increases. By harnessing the energy in falling water, hydroelectric power plants produce hydropower, or electricity. The falling water drives turbines (water wheels) that are connected to electric generators. The amount of electricity generated by these spinning turbines depends on the volume of the flowing water and the distance the water can be made to fall, known as *the head*. With the flatter terrain of the plains, hydroplants on rivers like the Kaw must operate with low heads. Low head plants optimize electric output by employing large slow-speed turbines that use high volumes of water.

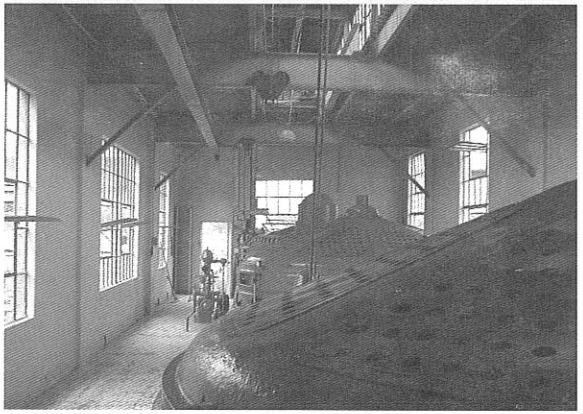
Electricity at Bowersock

The Bowersock Mills & Power Co. is a low head, run-of-the-river hydropower plant, meaning that it only uses the amount of water currently flowing in the river. As a result, power output is subject to fluctuations in the water level due to rainfall, snowmelt, and the release of water from upstream dams. The Bowersock dam employs flash boards that raise the level of the head water in order to increase production.



A view of the dam showing both the pneumatic flash boards on the left and wooden flash boards on the right.

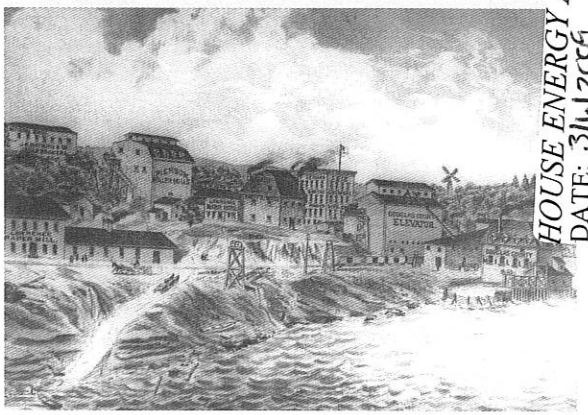
The falling water spins seven turbines that are connected by shafts to generators in the powerhouse. These generators produce power at 2,300 volts and have a total capacity of 2,350 kilowatts, enough to serve approximately 1,500 homes. The electricity is transmitted to the electric grid via the 6th Street Substation where transformers step the electricity up to 12,470 volts for efficient distribution. When the electricity gets to your house, its voltage is lowered to 120 volts for safe usage.



Three of the seven generators at Bowersock.

History of Bowersock Mills & Power

In 1872, Orlando Darling, a local builder, began work on the dam at Lawrence. In 1878, after several floods and a bankruptcy, Justin DeWitt Bowersock acquired the dam. At this time, the dam produced mechanical power (not electrical) that was transported to local businesses via a belt-and-pulley system. However, floods regularly damaged the facilities. A huge ice jam above Lawrence broke in 1888, sending a wave of water and ice into the dam and mills. The dam held, but the water and debris rushed under the mill tearing out the turbines, belts, and pulleys. Since the belts were attached to machines in neighboring businesses, some proprietors saw their machinery carried first down the streets of Lawrence and then down the Kaw.



Artist's rendering of the old Lawrence riverfront. Note: The Bowersock Mills (far right) and the support tressels (center) for the belt-and-pulley energy conveyance system to neighboring businesses.

As an admirer of Thomas Edison, Bowersock added the first DC generator in 1886, only 5 years after Edison established the world's first power plant in New York City. *Thanks to J. D. Bowersock, Lawrence was one of the earliest frontier towns to have the convenience of electric power.* The availability of cheap, reliable power helped Lawrence to become the predominant manufacturing center on the early frontier. Early customers of Bowersock were the Consolidated Barb Wire Co. (Kansas' largest employer), several flour mills, the City of Lawrence, the Bowersock Theater (now Liberty Hall), and the Lawrence Journal and the Lawrence World.

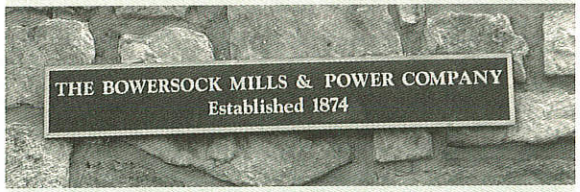
After the 1903 flood, the plant was rebuilt by 1905 using concrete and brick, and converted from DC to AC generators in 1920.

Bowersock Today

Bowersock has continued to operate into the twenty-first century. Today, The Bowersock Mills & Power Company is the oldest producing power station west of the Mississippi and is still an integral part of the Lawrence community.

- **The Bowersock dam ensures the Lawrence water supply.** The intake valves for the Lawrence water system are located beneath the reservoir of water above the dam. *Continued maintenance of the dam is essential to ensuring a safe water supply for a growing city.*
- **Bowersock generates enough electricity for 1,500 Lawrence homes and businesses—11 million kilowatts-hours or more per year.** This electricity is pollution free. No greenhouse gases or acid rain producing sulfur compounds are emitted.
- **The Bowersock reservoir provides habitat for the bald eagle, our national symbol.** Every winter you can see bald eagles fishing near our dam. Check our web site (www.bowersockpower.com/technical.html) for daily updates during the winter.

Bowersock "firsts" include Lawrence's first: sanitary sewer; passenger elevator; steamheated building; and fireproof building.



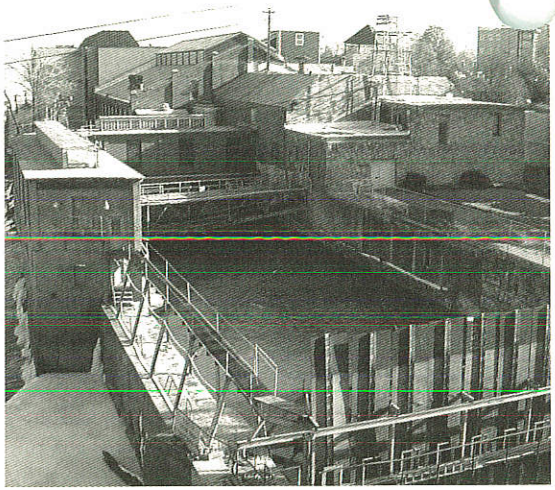
4-2

The Challenge Ahead

The Bowersock Mills & Power Company's existence is fragile. The business has been family-owned for over 120 years, but it has lost money over half the time during the last 21 years. The next set of major repairs needed for the century old plant may put it out of business. Independent producers of renewable energy in Kansas, such as Bowersock, are not allowed to compete on the open market, but may only sell their electricity to the local public utility. This lack of freedom stifles new energy producers, like wind farms, and could soon lead to the demise of existing producers, like Bowersock.

Tell your
Senator and Representative
that you support
Renewable Energy
http://da.state.ks.us/phonebook
House of Representatives &
Senate: 785-296-2391

Kansas is blessed with a number of potential renewable energy sources. With proper incentives, we could increase the capacity for hydropower here at Bowersock, and the large (third in the nation) capacity for wind power in the Flint Hills and the western plains of Kansas could be tapped. **If renewable energy producers are allowed to compete on the open market for your electricity needs, renewable (clean) energy production can flourish in the state.** Bowersock could expand, farmers could collect rent from wind farms located on their property, and the state would see an influx of revenue from the sale of excess energy. *All without polluting your environment.*



The Bowersock Mills & Power Company

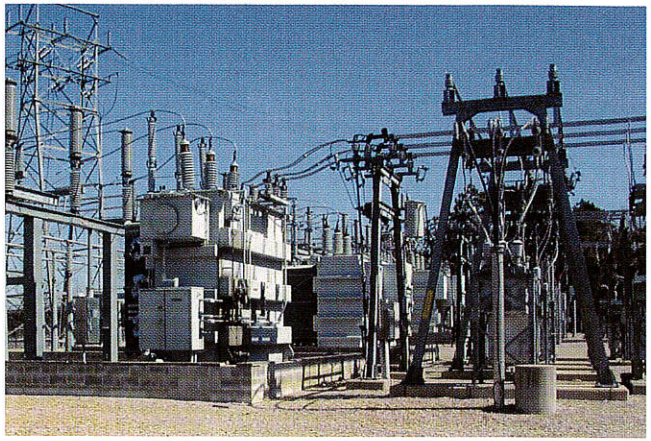
THE BOWERSOCK MILLS & POWER COMPANY

Kansas' Largest Hydropower Facility

P.O. Box 66
Lawrence, Kansas 66044
785-843-1385
e-mail: staff@bowersockpower.com
www.bowersockpower.com

(Guided tours are available)

From the transformer, three wires enter homes or businesses. Two of the wires carry 120 volts each and the third is neutral. Most home electrical devices operate on 120 volts, but the second wire entering the home allows people to operate high-energy appliances like air conditioners and clothes dryers. These high energy appliances take 240 volts which is the combined voltage of the two wires. The neutral wire completes the circuit.



The Bowersock substation is located on the NW corner of 6th and Massachusetts. You may have driven by it numerous times without realizing it is there. Professional landscaping has blended it into its urban environment.

How do we measure electrical usage?

The amount of power transmitted in an electrical current is equal to (volts x amps) and is called **watts**. 1,000 **watts** equal 1 **kilowatt**. When people use electricity in their homes the utility company bills them by kilowatt-hours (kWh). This is a measure of how much power a consumer uses multiplied by the number of hours they use it. For example, if a consumer was to burn a 100-watt light bulb for 20 hours, he or she would have used 100-watts x 20 hours = 2,000 watt-hours or 2 kWh.

Energy produced by power plants is measured in megawatts. One megawatt = 1 million watts. A 100-megawatt power plant can supply electricity for one million 100-watt light bulbs at any given time. Year 2000 US generation capacity was about 640,000 megawatts (EIA).

What can go wrong?

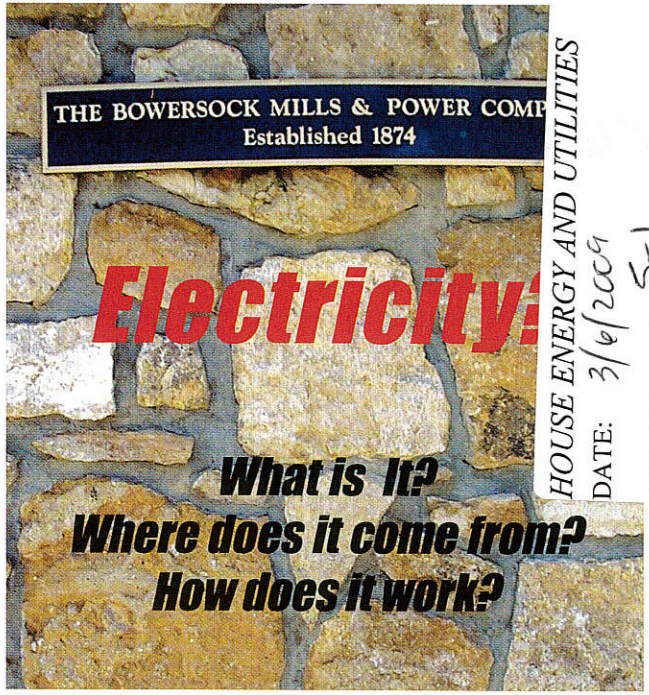
In general, electricity in the United States is produced and distributed in a safe and efficient way. Problems arise primarily when this complete circuit is interrupted. The earth is like a big reservoir for electrons, so if an electron in the circuit can find a more direct, but unintended, path to the earth, it will take it. In order to prevent electrons from leaving their intended path, power lines are coated with an insulating material. If they were not coated, the electrons flowing within the wire would take the shortest path to the ground, flowing through whatever was touching both the wire and the ground. This would not only prevent electricity from reaching its intended source, but would also create serious hazards, including fire and electrocution.

The United States' electric service reliability is very high - over 99%. However, the greatly expanded demand for electricity brought on by modern technology and our increasing population has created an energy shortfall in the United States. Companies that provide electricity need to be able to provide enough power to meet the requirements of users during times of maximum use (peak demand). The generally accepted rule of thumb for producers of electricity is to have enough reserve capacity to produce power at 20% over peak demand.

In 2001, states such as California were unable to meet the demands of all users. To protect the electric grid and to insure that vital services, such as hospitals, would retain power, companies that provide electricity were forced to decrease the voltage to selected areas (brownouts), or cut off the power altogether (blackouts). During brownouts, electrical customers do not receive all the electricity that they attempt to access. In this situation light bulbs are dim instead of bright, appliances do not work efficiently, if at all, and some devices, such as computers, may even be damaged. During blackouts, customers do not receive any electricity.

The Bowersock Mills & Power Company generates enough electricity for 1,800 Lawrence homes and businesses. This environmentally safe energy source helps meet the power needs of the growing and vibrant Lawrence community.

Disclaimer: This material was prepared with the support of the U.S. Department of Energy (DOE) Grant No. DE-FG48-97R802102. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of DOE.



Electricity is a secondary source of energy. It must be extracted from a primary source of energy, such as coal, petroleum, natural gas, wind, sunlight, or moving water. Since humans have learned to generate and control electricity, it has become one of our most important and convenient forms of energy. Electricity's greatest asset is that it is easy to transport; it can be sent through tiny wires to its destination, such as the lights in homes.

In order to understand electricity, one must first understand the basic composition of matter. All matter is made up of molecules, which are combinations of tiny particles called atoms. Atoms are composed of three types of even smaller particles: neutrons, protons and electrons. Protons carry a positive (+) charge, electrons carry a negative (-) charge, and neutrons have no charge. Electricity is the flow of electrons from one atom to an adjacent atom. This phenomenon is usually invisible to the naked eye, but can be seen in an extreme and uncontrollable form --- lightning.

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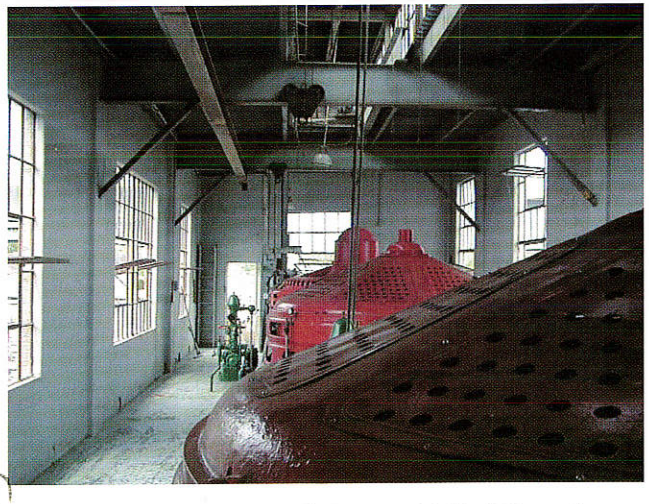
Two Types of Electricity
There are two types of electricity**: direct current (DC)** and **alternating current (AC)**. With DC electricity, the electrons flow directly from point A to point B. Batteries produce DC electricity.

With AC electricity, the electrons oscillate (move back and forth) along a power line. On the North American power grid, electrons oscillate 60 times per second (60 hertz). The electrons' movement can be compared to water sloshing back and forth in a hose. Energy is extracted from these oscillating electrons

Where does electricity come from?
Electrical power is produced when a magnet moves over a wire made of conductive material – usually some type of metal. Copper is the second best and cheapest conductor of electricity. Any power generating machine consists of an electromagnet on a rotating shaft surrounded by a ring of tightly bundled (usually copper) wires. Wrapping the wire in a ring around the electromagnet exposes many sections of the wire to the electromagnet (called a rotor) which spins inside the copper coil and produces power (electricity). The cumulative effect of the magnet passing over many sections of the wire increases the power produced. The larger the generator (the larger the electromagnet and the greater the number of wires exposed), the greater the amount of electricity produced. Almost all electricity on the electric distribution grid is generated by the above method.



Three of seven generators at The Bowersock Mills & Power Company. Bowersock has been producing clean renewable energy for the Lawrence community since 1874.

The majority of electricity is generated using one of three **prime movers**: steam, water, or wind. Steam is generated by coal-fired and nuclear power plants that boil water to produce steam. The escaping steam is used to turn the rotors. Hydroelectric plants use running water to spin the rotors and wind turbines rely on the force of the wind.

Above: A typical transformer in an older neighborhood that reduces electricity to 120 volts so it may be used in homes and businesses. Note the 3 wires. Two contain 120 volts each and the third is a ground wire. In neighborhoods with underground utilities the transformer is in a box located on the ground.

How does electricity work?
For electrical energy to be transferred, it must have a complete path, or circuit, through which electrons can be transferred. A circuit is the complete path for current flow from the source of electricity through one or more conductors back to the source. Three factors effect every circuit: **voltage**, **current**, and **resistance**.

Just as water pressure causes water to flow through a hose, an electrical pressure (difference in potential) causes current to flow through conducting wires. This difference in potential is called **electromotive force (emf)** but it is more commonly referred to as **voltage**, which is measured in **volts**. The higher the voltage or pressure, the greater the flow of electric current. Electric current is measured in **amperes (amps)**. Amps indicate the amount of current going by any one particular place at any given time.

As electricity flows through conducting material it encounters some resistance, which is measured in **ohms**. Materials that offer high resistance to current flow are called [illegible]tors. Materials that offer little resistance to flow ar[illegible]d conductors. Copper offers little resistance and is therefore a good conductor. Glass offers significant resistance and is therefore a good insulator.

In every case, electricity must always complete a circuit. Once the electricity has been used (for example: in a home appliance), the circuit is completed as the electrons eventually make their way back into the earth – most commonly through the neutral wire.

How is electricity distributed?
After electricity leaves the generating plant it goes to a **transmission substation** where the voltage is increased to 161 – 765 thousand volts. This high level of voltage is needed to push the electricity through the **grid**, which is the network of power lines and transmission substations through which power is carried across the country. As power is transmitted through the power lines, some power is lost, but the higher the level of voltage in the lines, the less power is lost. High voltage lines made of steel-reinforced aluminum cable limit the loss of power and have extended transmission distances up to 300 miles.

Once the electricity reaches the area where it is to be used, it goes to a **distribution substation** where the voltage is stepped down to the standard residential power line of 7,200 volts. The distribution substations act as watchdogs for the power lines, as they contain circuit breakers, or safety switches, that trigger in the event of a power surge such as a lightening strike or short circuit. Once the power is stepped down, the distribution substation routs the electricity in various directions.

How do we use electricity?
All home electrical appliances in the United States, such as lights, washing machines, and televisions work on either 120 or 240 volts. Since the voltage in distribution lines is 7,200 volts, it must be decreased by a transformer before it is used in a home or business. Transformers in older neighborhoods are gray cylinders located near the top of power poles. In newer neighborhoods, power lines ha[illegible]n placed underground and transformers are large (3-4 ft.[illegible]e) gray or green metal boxes located on the ground.