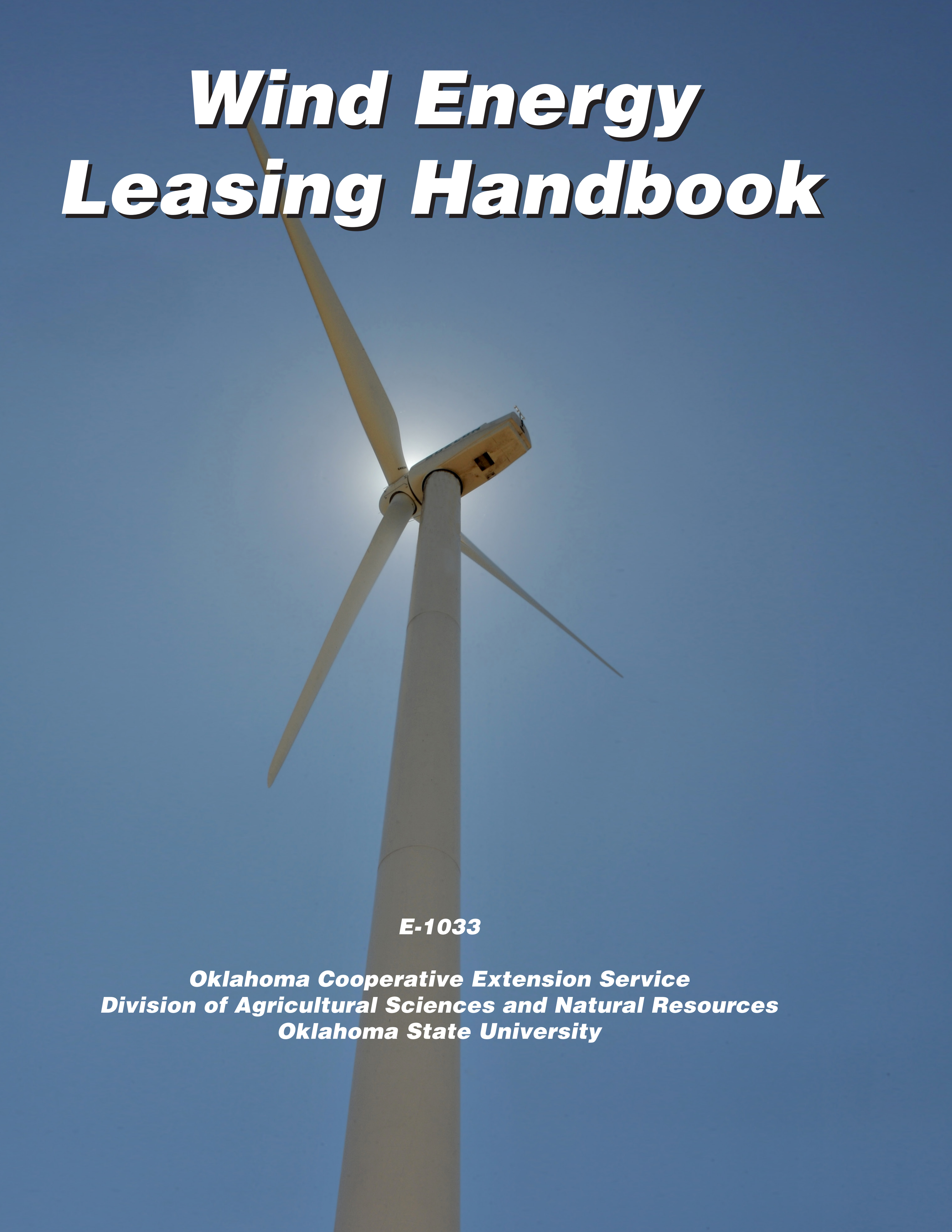
Wind Energy Leasing Handbook



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Understanding the Electrical Power Industry

Objectives

After reading this section, you will understand:

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What is electricity?

Electricity is an immensely important part of modern life. We use electricity to keep us cool in the summer and warm in the winter, to provide light in the dark, to cook our food, to power the machines that make other products, to process and move agricultural goods, and increasingly, to get us from place to place. But what is electricity, anyway?

To answer this question, we start with the atom. All matter is made up of atoms. Atoms, in turn, are made up of three basic kinds of particles. The nucleus, or center, of the atom is made up of protons and neutrons. Electrons orbit around the nucleus. Importantly, protons have a positive (+) charge and electrons have a negative (-) charge (neutrons have no charge). As long as the atom has the same number of protons and electrons, the positive charge of the protons and the negative charge of the electrons balance each other.

Strong forces hold the nucleus of the atom together, but the application of a relatively small amount of energy to the atom can knock an electron out of its orbit. Once we do this, the atom has more protons than electrons and has a positive charge. Similarly, the electron now represents a lone negative charge. The electron wants to find another nucleus to orbit, and once it does, it transfers the energy it carries to that atom. That energy transfer may knock another electron out of its orbit, and so on. As we keep applying energy, more and more electrons jump from atom to atom. This flow of electrons is what we typically call electricity or current.[1]

How is electricity generated and moved?

To move electrons, we need some source of energy to act on the atoms and knock the electrons from one atom to another. We also need a pathway of atoms for the electrons to move along; electrons must have a new atom to orbit or they will strongly resist being moved.

Generally speaking, there are two ways to deliver the energy that moves an electron from one atom to another. Applying a magnetic field to the atoms can move the electrons from one atom to another since electrons react strongly to such fields. This is the process used in both electric motors and electric generators, as a magnet is moved through an electrical field or vice versa. In a way, this is also how solar cells (also called photovoltaic cells) generate

1 An abundance of electrons that are not flowing is often called static electricity.

electricity. Light particles called photons are actually tiny packets of electromagnetic energy, which strikes the atoms in the cell, knocking electrons from atom to atom and generating an electrical current.

The other way to cause electrons to move from atom to atom is by a chemical reaction that causes the substances in the battery to exchange electrons. Batteries are made up of three basic components: (1) a cathode which forms the positive side of the battery and is made up of a substance that wants to accept electrons, (2) an electrolyte, which is a substance that makes the exchange of electrons easier, and (3) an anode which forms the negative side of the battery and is made of a substance that wants to give up electrons. For example, in an alkaline battery, the cathode is manganese dioxide, the electrolyte is zinc chloride, and the anode is zinc. The chemical process in the battery causes an excess of electrons at the negative end of the battery, and these electrons want to move away from one another. Since they are prevented from moving toward the positive end of the battery by a separator within the battery, they will move through a circuit when one is connected to the battery.

While magnetic fields and chemical reactions are the most common ways we create a flow of electrons, there are other ways electrons can be moved as well. For example, when pressure is applied to some substances, they generate very small amounts of electrical current. This is how microphones and some electronic scales work. In other substances, applying heat can create a small flow of electrons, and this is how some thermometers measure temperature. The processes of using pressure and heat to cause electrons to flow can be very useful, but they produce only tiny amounts of electricity.

Once we have created an abundance of electrons, we need to provide a path for them to move along in order to accomplish any work. Conductor materials such as copper, aluminum, and iron (or steel) are made up of atoms with electrons that easily leave their orbits and move to other atoms make the flow of electrons possible. A pathway for the electrons to follow from their source (a generator or battery) through a conductor and back to their source is called a circuit. Electrons must have a complete circuit before they will flow. This is because electrons do not want to move from one atom unless there is another atom nearby. Otherwise, they will go nowhere. To see this, connect a wire from one end of a battery to a switch and a bulb, and then connect the switch and bulb with a wire attached to the other end of the battery. Close the switch, and electrons flow through the circuit lighting up the bulb. Open the switch and nothing happens because the electrons cannot flow.

If the atoms of a material do not readily give up their electrons, this hampers the flow of electricity, and we call the material an insulator. Insulators serve a valuable role in moving electricity too, as they form barriers that prevent the electrons from going where we do not want them to go.

How is electricity measured?

As we discuss electrical systems, we need some terms to describe what happens to the flow of electrons. As we do this, it might help to think of something else that flows: water. So, before we begin, think of a water system with a water tower on top of a hill, a series of pipes,and a number of taps for its customers.

One thing we care about with a water system is the amount of flow and we often measure flow in gallons per minute. In other words, we ask how much water passes by a given point during a given amount of time. With electricity, we are dealing with the flow of electrons, so it makes sense to measure how many electrons flow past a given point during a given amount of time too. Instead of gallons per minute, we must count electrons per second. Since electrons are so very small, we must count a lot of them. We call 6.289×10^{18} electrons (or more than sixty quintillion – that is a 6 with eighteen zeroes after it) a coulomb. A coulomb passing by a given point in one second is called an ampere which is usually shortened to amp. You may also see it represented by the symbol “A.”

Another thing we care about in a water system is the amount of pressure, because pressure, combined with flow, can sometimes determine how much can be accomplished by the water. We often measure water pressure in pounds per square inch. Electrons do not exert this kind of pressure on their conductors or on devices that use them, but there is an analogy that can help us. How do we move water through pipes? We either put a water tank in a high place so that gravity wants to pull the water down and away from it, or we put pumps in the system to push it along. In other words, we create something that puts pressure on the system, knowing that water wants to move from an area of greater pressure to an area of lesser pressure. When water is raised in a water tank or put under pressure, we say that it has potential energy. That energy isn't released until the water starts moving. The same principle holds true for electrical circuits. Electrons try to repel each other (remember that like charges repel, and opposite charges attract), so where we have an abundance of electrons, they want to get away from each other to an area where there are not as many. Until they start moving, the electrons only have potential energy. Just as pressure on a water system makes the water want to move, a difference in electron concentrations between two points in an electrical circuit creates a difference in the potential flow of electrons between those two points that tries to push electrons between those points. That force is called electromotive force or "EMF." We measure this force, or pressure, with units called volts and represented by the symbol "V." In electrical equations, this force is represented with either the letter "E" (for electromotive force) or "V" (for voltage).

So how do we define what a volt is? To answer that, we have to talk about the other concept in measuring electricity: resistance. In a water system, there may be a number of things that try to prevent the flow of water through the pipes. Friction along the walls of the pipes or blockages can slow the flow of water. Similarly, if we place something that is not a good conductor in an electrical circuit, we will slow the flow of electrons. We measure the ability of a substance to resist the flow of electrons in units called ohms. This is often represented with the Greek letter omega, or Ω. In electrical equations, resistance is represented by the letter R. All substances – even the very good conductors – have some level of resistance.[2]

2 There are certain substances called superconductors that have almost no resistance to the flow of electrical current, but as of now they are relatively rare and are not frequently used in producing and transmitting large amounts of electricity.

So how do these factors work together? We define a volt as the amount of pressure or force needed to push one coulomb through one ohm of resistance for one second. This means you can define an ohm as the amount of resistance that would allow a current flow of one ampere if one volt of force were applied. The relationship between current (flow), voltage (pressure) and resistance is always constant in an electrical system, and can be expressed like this:

$$I\ (Current) = \frac{V\ (Voltage)}{R\ (Resistance)}$$

This is called *Ohm's Law* and governs how all of our electrical circuits work. Once you understand this relationship, many aspects of electrical systems become clear.

Before we leave this discussion, we need to address one more aspect of measuring electricity – the capacity of electricity to do work. Work in the realm of physics is defined as force acting on a mass across a distance (for example, when you push a weight over a given distance, you are producing work). In discussing electrical circuits, we define work as the action of an electromagnetic field moving electrons through a resistance. When one ampere of current moves though an electrical potential difference of one volt, this is a watt ("W"). Work performed over a given amount of time constitutes energy and in the electrical industry, energy is often measured in watts over time. For example, doing one watt of work (power) continuously for an hour (energy) is a watt-hour. Doing one thousand watts of work continuously over an hour would be a kilowatt-hour (kWh) of energy. The use of electricity for homes and businesses, and the production of energy by small generators is often measured in kWh. For example, the average U.S. home has a peak electrical demand of between three and five kilowatts.[3] If a home used this amount of energy over an hour, it would consume three to five kWh of energy. Doing one million watts of work for an hour would be a megawatt-hour (MWh) of energy. The use of large industrial facilities, and the production of energy by large utility generators is often measured in MWh.

3 Understanding Today's Electricity Business, p. 3.

How do electrical generators convert other forms of energy into electricity?

We know from the previous discussion that to make electrons move through a circuit, we need to do something that causes a buildup of electrons under pressure at one point so that we can push those electrons through the circuit and then back to their source. How can we do this?

We discussed above that there were primarily two ways to generate current – through using magnetic fields and through chemical processes. Chemical processes tend to produce relatively smaller amounts of current, so while they may be ideal for providing portable power in the form of batteries, they generally cannot provide the power needed for larger demands like multiple homes, industrial machinery, and so on. Thus, we need something capable of producing much more current at higher voltages.

Long ago, scientists discovered a principle called *Faraday's Law*. *Faraday's Law* tells us that if we pass a conductor through a changing magnetic field, a voltage is created. In other words, the electromagnetic field acts on the electrons in the conductor, creating the pressure that makes the electrons want to move. To see this in action, connect a length of wire to a voltmeter and then pass a magnet near the wire. As the magnet moves past the wire, the voltmeter will move, indicating that a voltage was created. If you hold the magnet still, though, nothing happens. Thus, movement through the magnetic field is required.

If you kept experimenting with this system, you might find that there were a couple of ways to increase the voltage you observe. You could create some coils in the wire and you would see that with every coil that passes through the magnetic field you are increasing the amount of voltage produced. This is because with each coil you are increasing the length of wire passing through the magnetic field in a given amount of time. You could also move the wire by the magnet faster and see that this too increases the voltage. Using a stronger magnet would also increase the voltage.

What you have done is create a very simple electric generator. The massive electrical generators used by utility companies to produce power for thousands of customers at a time use exactly the same principles – they just operate on a larger scale. In a typical utility generator, a series of tightly wound wire coils called a stator are placed around a spinning electromagnet called a rotor. The only difference between this and our homemade generator is that we moved the wires and the magnet stayed still. In the generator the wires stay still and the magnet moves. By spinning the rotor inside the stator, we are constantly moving the magnet past the coils and constantly generating a voltage. Importantly, this voltage changes as the rotor moves past the stators – this will be discussed later.

As we learned from our experiments, moving the coils and magnet relative to each other is what produces the voltage and thus current, so we need to find some source of energy that can be continuously applied to the rotor to keep it spinning. We also learned that the faster we move the coils and magnet, the more voltage, and thus current, we can produce. This is what makes generators so flexible; we can use a number of energy sources to generate electricity so long as we can convert that energy into a rotating motion to propel our generator.

Where can we find this energy? It can come from a number of sources, and we will discuss some of the most common forms below.

Coal

The largest single source of energy for the United States is coal. In a typical coal generation plant, coal is burned in a combustion chamber to release heat. Temperatures in these chambers reach well over 1,000 F, and water is then passed through tubes in a boiler coupled to the combustion chamber to turn the heat into superheated steam at pressures of more than 2,000 pounds per square inch (psi).[4] This steam is directed through the blades of a turbine, where its tremendous pressure pushes the blades, causing them to rotate. The turbine blades are connected to a rotating shaft, which is connected to the rotor of a generator. As the

4 Electric Power System Basics, p. 24.

shaft spins, the rotor moves past the stator, generating electricity.

Because it takes time to get a combustion chamber and boiler up to their most optimal operating temperatures, coal generation plants are most efficient when they can run at a consistent level, day and night. Conversely, they become less efficient when they are forced to increase or decrease their output. This impacts how they are used in conjunction with other generators, as we will discuss below.

Nuclear

Nuclear power plants work in much the same way. The difference is that instead of burning coal, a controlled nuclear reaction is used to generate the heat used to create steam. In a nuclear reactor, highly-refined nuclear fuel (usually enriched uranium) is used. The atoms of uranium have a very large number of protons and neutrons in their nucleus, and this nucleus is very unstable as its neutrons frequently break free and release energy from the nucleus as a result. These neutrons then slam into other nearby atoms, breaking apart their nuclei as well, forming a chain reaction. These reactions generate a tremendous amount of heat, which is used to convert water into steam. The reaction is controlled using control rods that absorb the neutrons and slow down the reaction. This is the primary difference between a nuclear reactor and a nuclear weapon. In nuclear weapons, the reaction is uncontrolled and rapidly converts large amounts of the fuel into energy. In a nuclear reactor, fuel is used very slowly, which is why a small supply of fuel may last a reactor for many years.

Nuclear plants can take even longer than coal fired power plants to reach their optimal temperature, and this too affects how they are used to produce power.

Natural Gas

Natural gas can also be burned as a fuel to create heat make power in basically the same way as coal or nuclear power. These generators are sometimes called natural gas thermal generators. Like coal-powered generators, these generators can also take some time to bring into operation.

However, some electrical generators use natural gas in a different way. Natural gas can be used as a fuel for turbines almost identical to those used as jet engines (which are themselves turbines). Natural gas is burned in the combustion chamber of the turbine, causing the turbine blades to spin. As with other turbines, these blades are connected to a shaft that is used to spin the generator's rotor. These generators can be brought into operation very quickly, and can be used to provide power when it is needed on short notice. These generators are sometimes called gas turbine generators.

There is another form of electrical generation from natural gas that recycles some of the thermal energy from combustion of the natural gas. In these systems, natural gas is first burned in a gas turbine generator to produce electricity. This process creates heat as well, and this heat is then used to turn water into steam that is then used to propel a steam turbine that produces additional power. These systems are called natural gas combined cycle generators.[5]

Water (Hydropower)

Water can be used to turn a generator as well. For centuries, mills placed water wheels in the flow of a stream of river, allowing the force of the moving water to push the wheel and thus rotating millstones or other machinery. That basic principle is slightly modified to power modern hydroelectric power plants. Typically, a dam is placed across a river to raise the elevation of the water. With this increase in elevation, the water has more potential energy (as discussed above). This water is then released through a water outlet, where it flows down a tube called a penstock and into the blades of a water turbine. As with all the other turbines discussed, this causes the blades to rotate a shaft which is connected to the generator, providing electrical power.

Wind

With all this talk of mechanical forces pushing the blades of a turbine to generate electricity, you can probably guess how a wind turbine works; the wind passing by the blades of the turbine turns the rotor. This is just like the other kinds of generators, with two exceptions. First, since the blades of a wind turbine are so

5 Understanding Today's Electricity Business, p. 39.

large, they must turn at a relatively slow rate to avoid being damaged. As a result, the rotor is connected to a transmission that turns the slow but powerful rotation of the blades into a much faster rotation that is used to move the rotor inside the generator. Second, wind cannot be controlled and thus the turbine can only generate power when wind is available. For a fuller explanation of how wind turbines work, see the chapter on the wind power industry.

The Power Portfolio

Different circumstances suit some generator technologies better than others. As we discussed above, generators that rely on heat take a long time to reach their most efficient operating state, but they may also be the least expensive to operate. On the other hand, natural gas turbines and hydropower can be operational in a matter of minutes, but natural gas generators can sometimes be costly to operate, and hydropower dams may need to conserve water. Since, at least right now, there are no technologies that allow us to store electricity for later use (at least, at the scale needed by utilities), and we can only use wind power when the wind is blowing. All of this means that utilities use a portfolio of generator technologies to provide their customers with power. This means that they rely on a combination of different generator technologies used in different amounts at different times to make sure that their customers have power when they need it, and at the lowest cost.

Utilities must make sure that their customers have the power they need when they need it. This is not easy because electrical demand is not the same throughout the day. At night, when people are asleep and many businesses are closed, less power is used. As people wake up and go to work, more energy is used. In the summer, electrical demand peaks in the late afternoon and early evening hours as temperatures rise and air conditioning is needed. This change in electrical demand over a day is called the load curve (Figure 1).

As you look at this curve, you see that there is a certain level of electricity that is always needed – electrical demand never dips below this amount. This is called baseload. Since this amount does not vary greatly, utilities often use generators powered by thermal resources, such as coal, nuclear, and natural gas thermal generators to provide this power. Some hydropower and renewable resources may also be used in baseload generation.

Beyond baseload, we can also see that there is another stage, if you will, where more electricity is demanded than during the baseload periods, but where the demand rises and

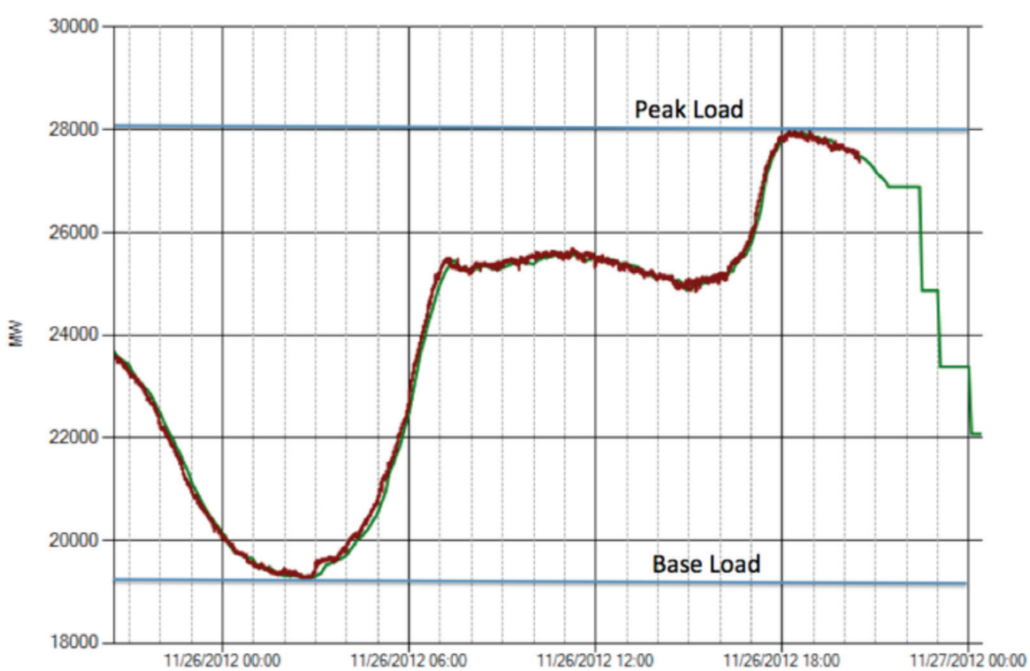


Figure 1. Load Curve for the Southwest Power Pool.
Source: Southwest Power Pool, http://www.spp.org/RealTimeLoad.html

falls slowly enough that generators have some time to respond. This is called intermediate load. These demands are often met with natural gas thermal generators, natural gas combined cycle generators and with hydropower.

Last, at the top of the curve, we see what is called peak load. This demand can change very quickly and puts the most strain on the electrical system. Think about 5 p.m. on a hot summer day. Everyone starts to arrive home from work and notices that their home is hot. They all turn on their air conditioners (which is often the largest single electrical load for their house) at about the same time. Demand for electricity across the entire area then sharply rises. As a result, the electrical utilities must be able to quickly respond with the amount of electricity needed to meet this demand. They need electrical generators that can be brought on-line quickly, so they often use natural gas turbines and hydropower for these periods.[6] Because sources used to generate peak power may not be as efficient as other sources, and due to market conditions, peak power can be very expensive compared to baseload power.

Where does wind fit in this discussion? As discussed above, utilities have to use wind power when it is available. Thus, the utilities need very accurate weather forecasts to help them know how much wind power will be available in the day ahead. They can then adjust the generation available from other resources to save other types of fuels when wind power is available. Gas turbine units are most often used for this task, since they can respond rapidly if the wind should stop blowing. Since Oklahoma has a large number of natural gas powered generation, this makes wind power a good fit for many of our utilities.

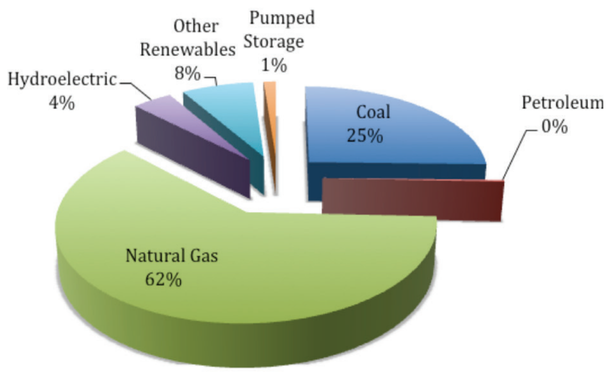
While research continues into a number of technologies that would allow us to store power when electrical demand is low and release it when demand is high, there are no such technologies that can operate at utility-scale right now. That means that utilities must coordinate their generation with demand in real time. Regardless of what energy source is being used to supply power, there must be sufficient reserve power available to make sure all customers have the power they need should a generator go offline for any reason. A certain amount of additional generation capacity must be available at all times and on a moment's notice to step in and provide additional power. This capacity is provided by generators that can respond quickly to changes in demand, and is often called spinning reserves because the generators are kept operational and running (spinning) when they are on call.

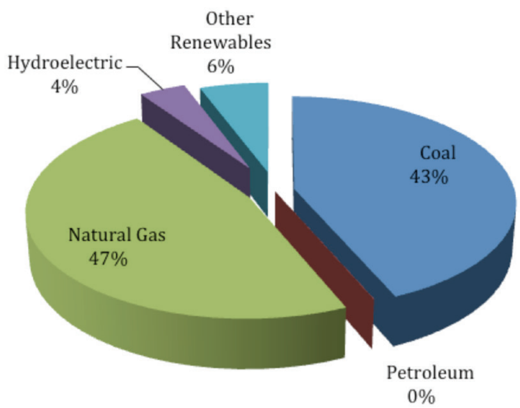
Someone has to coordinate all of these different kinds of generators to make sure enough electrical power is available to everyone who needs it. This is called dispatching the generators. In Oklahoma and the surrounding area, this is accomplished by an organization called the Southwest Power Pool (SPP). When it is determining which generators need to be used at a given time, SPP is functioning as an electrical reliability organization. SPP also carries out a number of other roles in our region, which will be discussed later.

Figure 2 shows the amount of capacity Oklahoma's utilities have in each type of electrical generation and how much power was generated by each type. As you will see, Oklahoma has more natural gas powered capacity than any other type, but we use more electricity from coal powered generators (which are used to provide baseload). Also note the amount of electricity that is now provided by wind power.

So far, we have talked about how utilities use different types of electrical generation to provide power to their customers. Sometimes, utilities also use demand response systems as an alternative to generating more power. In such cases, these systems allow the utility to request (or in some cases, command) customers to stop using certain electrical equipment. Customers usually receive reduced rates or other considerations for participating in these programs. This means less electrical power is required. Helping consumers use less power means the utility may not have to build new generating facilities, thus saving them and their customers additional costs. It also can reduce the emissions of greenhouse gases. This is why some utilities offer rebates on energy-efficient appliances or other incentives that encourage power conservation by their customers.

6 For a general discussion of how the load curve and generation dispatching is usually accomplished to meet it, see Understanding Today's Electricity Business, pp. 47-48.





*In both charts, Other renewables includes all renewables other than hydroelectric, but in Oklahoma, wind comprises almost all of this category.

Figure 2. Oklahoma Generation Fleet and Production.
Source: Energy Information Administration Oklahoma electricity profile, available at http://www.eia.gov/electricity/state/oklahoma/

What is the electrical grid?

Now that we have talked about the different ways electrical power can be generated, we need to talk about how to get that power to its users. To do that, we need a system of electrical circuits capable of reliably delivering large amounts of electrical power to a wide variety of customers. We call that system the electrical grid or the power grid.

We often talk about the national power grid, but that is not really accurate, since there is not really a continuous nation-wide network of electrical transmission lines. Instead, there are a series of regional networks called interconnections. All of these interconnections are overseen by an organization called the North American Electric Reliability Council, or NERC. NERC is not a government agency, but the governments of the USA and Canada have given it the authority to oversee the operation of the regional interconnections. There are four interconnects in North America. These are the Quebec Interconnect, the Eastern Interconnect (of which Oklahoma is a part), the Western Interconnect and the Texas Interconnect (sometimes called the ERCOT Interconnect, named after the Electric Reliability Council of Texas).

These interconnections operate independently, although almost all of them now have a limited number of connections with their neighbors to allow for the sale of power among them. These connections between interconnects require complex and expensive equipment as the phase and frequency of the power between the two interconnections must be synchronized.

Interconnections are composed of groups such as Independent System Operators (ISOs), Regional Transmission Operators (RTOs) and Regional Reliability Councils. These are non-profit organizations that operate under the jurisdiction of the Federal Energy Regulatory Commission (FERC).[7] They are managed by a board of directors made up of representatives of the generators, transmission systems, power marketers and government agencies in their territories.

ISOs and RTOs are responsible for coordinating the operation of the electrical transmission systems within their jurisdictions. A map showing the interconnections and their ISOs/RTOs is shown in Figure 3.

While ISOs and RTOs carry out the important task of coordinating the transmission of electrical power, the Regional Reliability Councils must coordinate the generation of power (which also includes the reliability and security of such generation). There are eight such councils in NERC.

SPP operates in Oklahoma, Kansas, and in parts of Texas, Arkansas and Louisiana. As you

7 The exception to this is ERCOT. FERC has jurisdiction over the interstate transmission of power, and since all of ERCOT is within the borders of Texas, it does not engage in the interstate transmission of power.

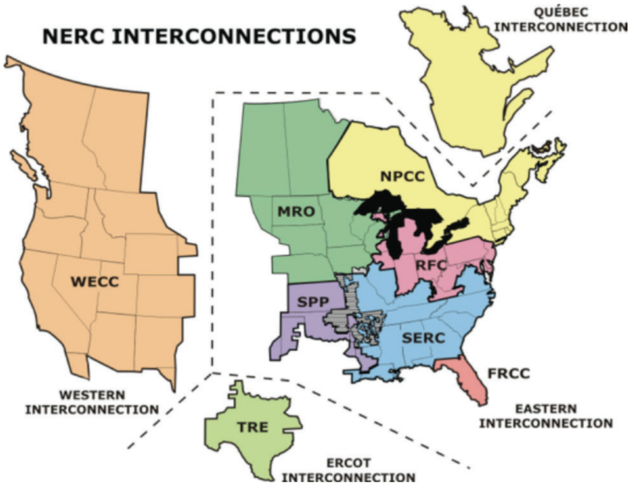


Figure 3. NERC Interconnections.

Table 1. NERC NERC ISOs and RTOs.

ISOs	*RTOs*
Alberta Electric System Operator (AESO)	Midwest Independent Transmission System Operator (MISO)
California ISO (CAISO)	ISO New England (ISONE)
Electric Reliability Council of Texas (ERCOT)	PJM Interconnection (PJM)
Independent Electricity System Operator (IESO) (Ontario Hydro) New York ISO (NYISO)	Southwest Power Pool (SPP)

Source: Electric Power System Basics, p. 183

Table 2. NERC Regional Reliability Councils

Electric Reliability Council of Texas, Inc. (ERCOT)
Florida Reliability Coordinating Council (FRCC)
Midwest Reliability Organization (MRO)
Northeast Power Coordinating Council (NPCC)
ReliabilityFirst Corporation (RFC)
SERC Reliability Corporation (SERC)
Southwest Power Pool, Inc. (SPP)
Western Electricity Coordinating Council (WECC)

Source: Electric Power System Basics, p. 183

can see from the Tables 1 and 2, SPP serves as both the RTO and Regional Reliability Council within its territory. This means SPP must accurately forecast how much power will be demanded by customers, coordinate generators to make sure that sufficient power is available and plan routes along transmission lines to make sure the power gets where it needs to go. SPP also is charged with doing this in a cost-effective way to make sure electrical rates stay at reasonable levels for customers.[8]

How is electricity transmitted from the generator to the user?

Generally, a vast network of high voltage power lines are used to accomplish this task.

Why do we use such high voltages?

When people use electrical power, they are trying to accomplish some form of work with that power. They are trying to generate heat, move machinery, create light, operate computers and so on. In our previous discussion, we said electrical work (and thus, power) is often measured in watts, and that a watt is defined as one ampere of current moving though an electrical potential difference of one volt. If we were to express this as an equation, it would look like this:

$$P\ (Power) = V(Voltage) \times I(Current)$$

So, if we want to get a large amount of power to electrical users, we have to either increase the amount of voltage or increase the amount of current. What would happen if we increased the amount of current?

We discussed the fact that virtually all electrical conductors have some amount of resistance that restricts the flow of electrical current through them. The amount of power lost to resistance in a conductor is a function of the amount of current and the resistance:

$$P(Power\ [lost]) = I^2(Current\ squared) \times R(Resistance)$$

8 Understanding Today's Electricity Business, p. 90.

This tells us resistance increases as a square of the amount of current we try to pass through a conductor.

This has a tremendous impact at the scales we use when discussing the transmission of power from utilities to customers. Let's say we are an electrical utility and we need to transmit one megawatt (i.e. 1,000,000 watts) of power to our customers. Power equals voltage times current, so we can use either higher voltages and lower currents, or lower voltages and higher currents to get this number. Now, let's say we have two choices: we can choose two voltages, a ten kilovolt (kV) line or a 100 kV line. To deliver a megawatt of power on the 10 kV line, we would need to use 100 amperes of current (10,000 volts x 100 amperes = 1,000,000 watts). To deliver a megawatt of power on the 100 kV line, we would need to use 10 amperes of current (100,000 volts x 10 amperes = 1,000,000 watts). Both lines have a resistance of 10 ohms (10 Ω).[9] How much power would we lose from each line?

From this example, you can see using higher voltages means we lose much less power that we would by using higher currents. [10]

Besides the efficiency issue, using higher currents and increasing resistance causes other problems. Resistance in a conductor almost always manifests itself as heat due to the fact that more and more electrons are bumping into each other, causing frictional heat. If we tried to transmit the amount of power needed by all of a utility's customers by increasing the amount of current, we would generate so much heat electrical lines would sag into trees and structures or melt (on days when electrical demand is very high, there is a lot of current flowing through the wires, and this phenomenon can occur). The only alternative would be to use much bigger wires. Such wires would be much more expensive, and would also require much larger transmission towers and poles.

So, using higher voltages gives us a more efficient electrical transmission system. By doing this, we can keep the current levels relatively low while still delivering the same amount of power. And as you see from the equations in Table 3, increasing voltage allows us to provide more power without any increase in resistance, which means less heat. This means increasing voltage rather than current allows us to use smaller wires, which allows us also to have smaller transmission towers and poles. All of this saves money for both electrical utilities and their customers.

Table 3. Comparison of Line Losses.

10 kV Line	*100 kV Line*
Power Lost = I^2 ***x R***	Power Lost = I^2 ***x R***
Power Lost = $(100)^2$ x 10	Power Lost = $(10)^2$ x 10
Power Lost = 100,000 watts	Power lost = 1,000 watts

Given this, we often classify electrical lines with voltages of 69 kV or more as transmission lines. Table 4 shows the most common sizes of transmission lines and their uses.

Using high voltages also decreases the amount of land taken up by transmission systems. One high voltage line can carry the same amount of power as many smaller lines, and thus only one smaller right-of-way is needed from landowners (Figure 5).[11]

Table 4. Common Transmission Line Voltage and Use.

Line Voltage	*Common Use*
69 kV	Distribution
115 kV	Distribution
128 kV	Distribution
230 kV	Extra High Voltage (EHV) threshold - transmission
345 kV	Transmission
500 kV	Transmission
765 kV	Transmission
1,000 kV	Ultra High Voltage (UHV) threshold - transmission

9 This discussion adapted from Basic Electricity, p. 3-5.

10 This discussion taken from Basic Electricity, p. 3-6.

11 Electric Power Systems, p. 49.

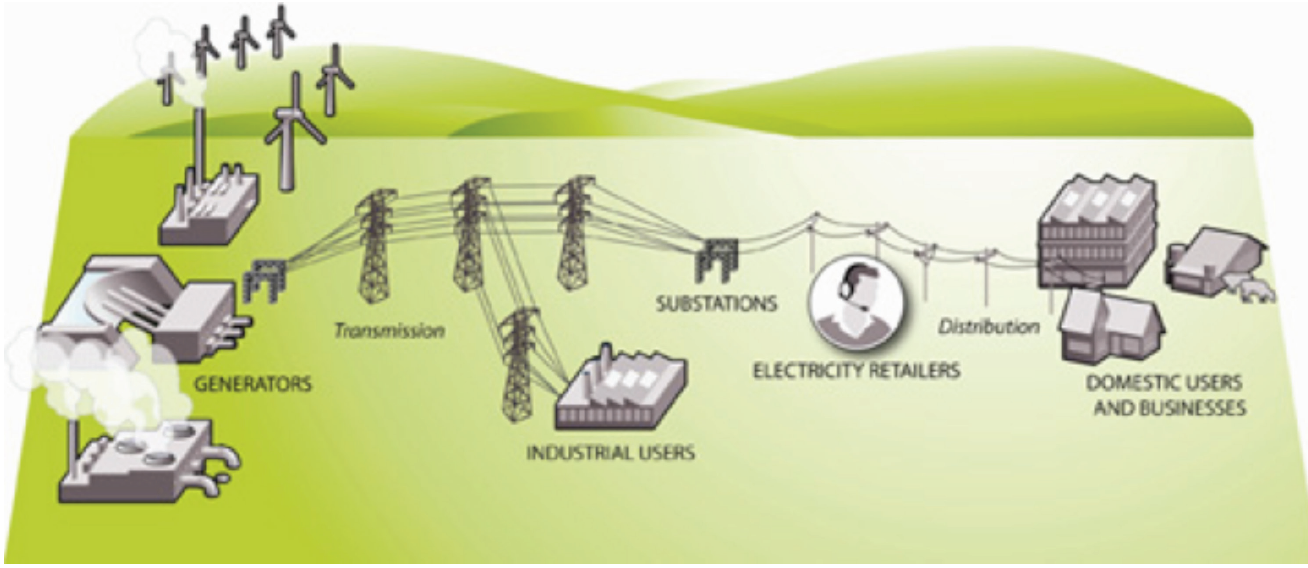


Figure 4. Diagram of electrical system

Source: New Zeland Ministry of Business, Innovation and Employment, http://www.med.govt.nz/sectors-industries/energy/electricity/industry

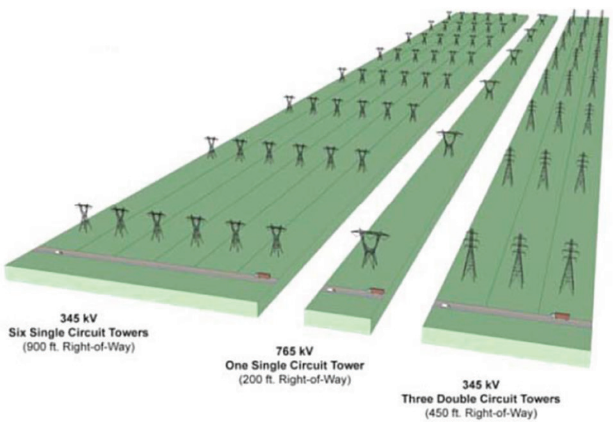


Figure 5. Diagram of Transmission Configurations

Source: SPP, http://www.spp.org/publications/Intro_to_SPP.pdf

Why do we use alternating current to transmit power?

We have established that high voltages are necessary for transmitting power – hence we need the ability to increase (or step up) voltages to transmit large amounts of power over long distances. Once power reaches its destination, though, we also need to reduce (step down) the voltage to a level that we can use in our homes and businesses. If we use alternating current for our power transmission, we can use a device called a transformer to increase or decrease these voltages (Figure 4).

The importance of transformers

Earlier, we noted that *Faraday's Law* tells us a changing magnetic field creates a voltage in a conductor. We also said passing an electrical current through a conductor creates a magnetic field around that conductor. Using these principles together, we can induce a voltage by passing a current through a conductor (the primary) whose magnetic field cuts across another conductor (the secondary). If we continuously vary the magnetic field produced by the primary, we also can continuously create a voltage in the secondary. We also can strengthen this transfer between the primary and secondary by linking them with a magnetic material, such as iron.

The number of coils in a wire affect how many magnetic field lines intersect the wire in a given space; this principle is what enables transformers to work. If both the primary and secondary had the same number of coils, the voltage created in each of them would be basically the same. However, if the number of coils in the primary were different than the secondary, the voltage would have to change. The relationship between the voltages in the primary and secondary is the ratio between the number of coils in the primary the secondary. If there are 100 turns in the primary and 1,000 turns in the secondary, then the ratio is 100:1,000 or 1:10. This means the voltage created in the secondary will be 10 times the voltage in the primary. This would be a step up transformer. On the other hand, if we reversed things, with 1,000 turns in the primary and only 100 in the secondary, the ratio would now be 10:1, and the voltage in the secondary would be 10 times less than the primary.

So, we can see how changing the voltage of power lets us adapt the flow of power to the needs of both transmission and the individual user. But what does this have to do with using alternating current (ac) power rather than direct current (dc)?

First, we have to explain the difference between direct and alternating current. Direct current, as the name implies, flows in one direction constantly. Alternating current, on the other hand, alternates the direction in which it flows. In the United States, electrical systems are designed around a system where the electricity completely changes its direction of flow sixty times per second (this is referred to as 60 Hertz or 60 Hz). These changes in direction do not occur instantly, though – the electrons begin to flow in one direction, slow down, and then begin to accelerate in another direction. If you were to measure this on a graph, it would look like Figure 6.

We call this a sine wave. This change in current is what enables us to use transformers to change voltage. If we pass ac current through the primary coil of a transformer, there is continuous change in the current. And since there is continuous change in current, there is continuous change in the magnetic field. According to *Faraday's Law*, changing magnetic field induces current. If we used direct current in our transformers, there would be no change in the magnetic field, and thus no current would be induced by the secondary coil.

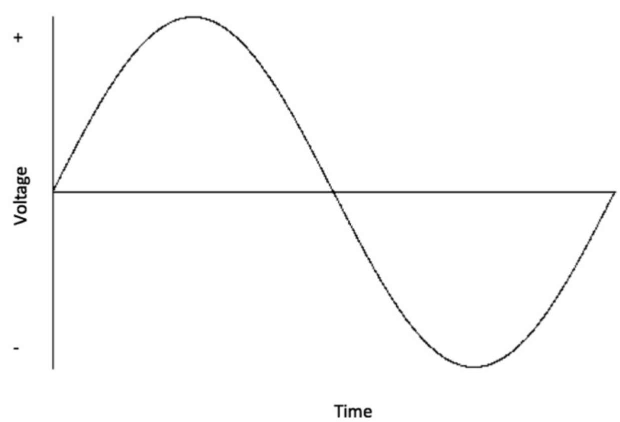


Figure 6. Diagram of AC sine wave.

Using dc power for transmission

Changing the voltage of dc power at the scale we need for transmission involves very complex and expensive equipment, and is generally impractical except for certain long-range transmission applications. If a large amount of electrical power needs to be transmitted a long distance, a dc line does have some advantages. First, it only needs two conductors rather than the three needed for ac electricity. This means less right-of-way is required, and towers can be constructed with less expense. Second, dc power has no frequency (as opposed to ac power, which has a 60 Hz frequency). This means it can be used to connect power systems that are not synchronized without expensive synchronization equipment. Third, dc transmission systems are used just to transport large amounts of power; they are not used to provide power to individual customers. This means the expensive equipment needed to convert dc to ac power is limited to the two ends of the transmission lines, which reduces cost.

The electrical transmission system

Now that we have discussed some of the basics of how we transmit electrical power from the generator to the user, let's talk about the electrical transmission system and its pieces.

Generator station

At the generator station, the utility will have the generator supplying the electricity, equipment to make sure that the power created is at the right frequency (60 Hz), and large step up transformers to increase the voltage from that of the generator to the voltage needed for transmission. The equipment needed to increase the voltage and to send the electricity along the proper transmission lines is often located in an area known as a switchyard.

Transmission lines and towers

Three materials are most commonly used to build electrical transmission lines (also called wires or cables): copper, aluminum and steel. Copper is a very good conductor, is durable, and is relatively inexpensive. Aluminum is not as good a conductor as copper, but it is lighter. Steel is not as good a conductor as copper or aluminum, but it is strong and is often bundled together with the other two to add strength to the transmission cable.[12] Multiple cables may be bundled together to increase the capacity of the line.

Running transmission lines above ground (this is also called overhead) keeps the transmission lines from coming into contact with anything on the ground that could short out the line (that is, create an electrical connection to the earth that would disrupt the circuit). Keeping transmission lines high overhead also reduces the risk of structures, trees, animals or people being injured by coming into contact with the lines. There are disadvantages to overhead lines, though. Keeping lines overhead exposes them to damage from lightning (though most lines have protective equipment to prevent this), wind, ice and other weather. Overhead lines take up space on the ground with their towers and are often regarded as negatively impacting the view of the landscape.

Given this, many people wonder why transmission lines are not kept below ground where they would be protected from weather and would not have as much of an impact on the use and enjoyment of the land. Underground transmission lines have their disadvantages, too. If underground lines are damaged, they may cause short circuits or stray currents (accidental flows of current running through the ground), which can cause injury to people or animals on the surface. To avoid these problems, expensive protective coatings must be applied to the transmission lines. If there is a problem with an underground transmission line, it is much more difficult to diagnose and repair than an overhead line since the line is not visible and must be removed or dug up to be repaired. All of these factors greatly add to the cost of underground transmission lines. Underground transmission systems usually cost between three to 10 times as much as constructing an overhead system with similar capacity.[13]

For these reasons, almost all large transmission lines are kept overhead except in areas where underground cabling must be used, such as near airports.[14] This means using large towers to keep the transmission lines far away from accidental contact with the ground. Towers also will have insulators that keep the transmission lines from contacting the tower itself and forming a short circuit or a circuit to anything on the ground. Many also will include lightning arrestors, which are wires or other devices that conduct the electrical discharge from lightning directly to the ground instead of through the transmission lines where it could damage the line or equipment connected to it. The kind of tower used depends on a number of factors, including the size of the transmission lines, the safety measures needed for that line, the surrounding terrain, and the cost of constructing the tower.

Electrical transmission is expensive to construct. Cost estimates for the various voltage ranges are presented in Table 5. As you can see, the amount of transmission line that must be built is a significant concern for utilities and their customers.

Right-of-Way

Transmission lines and towers need to go somewhere as they cross the landscape, and this means they will occupy part of the property

Table 5. Estimated cost of transmission construction.

Voltage	*Estimated Cost/Mile*
115kV	$130,000
230kV	$500,000
≥ 345 kV	$1,000,000

Source: Understanding Today's Electricity Business, p. 58

12 Electric Power System Basics, pp. 50-51.

13 Electric Power System Basics, p. 57.

14 Electric Power System Basics, p. 57.

held by landowners along their route. Typically this is done by purchasing a right-of-way from these landowners. A right-of-way (sometimes called a transmission line easement) gives the utility the legal right to go on to the property of the landowner for the purposes of building and maintaining the transmission line. Usually, the right-of-way will be defined as a line running along a direction and distance between two points on the border of the landowner's property, and will usually have a defined width on either side of that line. The right-of-way also will specify what the landowner can and cannot do within the path of the right-of-way.

Because securing rights-of-way is so important to operating the electrical system, Oklahoma gives certain utilities the power of eminent domain to secure rights-of-way if the landowner and the utility cannot negotiate an agreement. This means the utility can sometimes get a right-of-way without the landowner's consent. Nevertheless, the landowner must be paid a fair price for the right-of-way under both the state and federal constitutions.

The expense of obtaining rights-of-way, and the impact they have on landowner's use of their property is another reason why fewer high-voltage lines may be better than a larger number of lower-voltage lines.

Substations

The substation usually marks the point where we separate the transmission system (used to carry large amounts of power from the generator to near the location of its final use) from the distribution system (used to carry smaller amounts of power to the final point where the electricity will be used). You could think of the transmission system as the interstate highways and the distribution system as city streets. Substations, then, are the interchanges. Just as an interchange is designed to help vehicles safely transition from highway speeds to street speeds and find their final destination, substations reduce the voltage of the power to a level that can be used by the local distribution system.

Substations use a number of devices to accomplish this. Step-down transformers are used to reduce the voltage from that used in the transmission lines to that used in distribution lines. Devices called regulators also are used to make sure the voltage sent to the distribution lines does not vary so much as to damage equipment connected to the system. For U.S. systems, the target voltage is 120 V. Regulators work to make sure the voltage in the distribution system never varies beyond 126 V and 114 V. Circuit breakers are used to protect the substation and customers if there is a surge of current in the system. These breakers are much like those used in your home, but on a much larger scale. Some can be automatically re-set, and some must be manually reset. Large scale switches also are used to control the source of power or to re-route power when needed.

Substations may include a number of other devices to ensure the safety and quality of the power supplied to the distribution system. This can include lightning arrestors to avoid disruptions from storms, capacitor banks (capacitors can store large amounts of energy for a short time and discharge it quickly) to deal with temporary changes in voltages caused when large electrical loads turn on or off and control equipment, which allows the utility to monitor and diagnose the substation and the transmission/distribution system.

Some electrical users, such as very large commercial or industrial facilities, will have their own substations located on their property, as they accept transmission-scale power directly from the utility and use their substation to make the power conform to their needs.

Distribution Lines and Transformers

After the transmission-scale power has been reduced in voltage at the substation, it is then sent along smaller distribution lines to end users such as smaller businesses, homes and farms. We all recognize these lines as the lines that run near our houses. Often, a smaller transformer will be located on a pole where the distribution line branches into the business or home.

Table 6. Common distribution voltages.

System Voltage	*Voltage Class*	*Voltage Category*
Distribution or subtransmission	34.5 kV	High voltage
Distribution	25 kV	High voltage
Distribution	15 kV	High voltage
Distribution	7.2 kV – 601 V	High voltage
Secondary	Under 600 V	Low voltage

Source: Electric Power System Basics, p. 103

In neighborhoods, underground distribution lines may sometimes be used to avoid some of the issues with overhead lines. As previously discussed, these lines are more expensive and can be difficult to repair. With underground lines, access trunks and vaults (allowing the utility to reach connections between cables) and ground-based transformers are needed.

Business or home service entry

The electrical power is almost to your home or business now. The transformer mounted on the distribution pole or trunk will make one final step down to convert the voltage going to your house to 240 volts. Typically, there will be three lines (sometimes called legs) into the home or business: two 120 V hot wires and a neutral. Most of the circuits in your home will be wired by using one of the 120 V wires and the neutral, thus providing the 120 V power needed by many appliances, lights and other items in the home. Some items that demand a lot of power, such as air conditioners, electric clothes dryers, water heaters and ovens may require 240 V power. This is accomplished by using the two 120 V wires in combination.

These wires will first pass through an electrical meter. Your electrical meter is simply a watt meter that measures the amount of energy passing through it over time.[15] Thus, the meter records the amount of energy used in the circuits to which it is connected in kilowatt-hours (kWh). Remember, a kWh is the use of one kilowatt continuously over the course of an hour. The wires, having passed through the meter, then connect to a breaker box (sometimes called a service panel). This breaker box contains a series of circuit breakers that may bridge between the neutral wire and one of the 120 V wires to provide a 120 V circuit or between both 120 V wires and the neutral to provide a 240 V circuit. These breakers serve an important safety function. Recall that if too much current starts to flow through a conductor, it can generate a tremendous amount of heat. Thus, if there is a short circuit or other fault in a business or home circuit, this can dramatically increase current flow and thus create a risk of fire. The circuit breakers work to prevent this by opening themselves if too much current begins to flow in a circuit. This breaks the circuit, preventing any more current from flowing.

We have now gotten the power all the way from the generator to your home or business. But we also know that this process is not free, because we get an electric bill each month.

How do power companies buy power from generators and sell it to customers, and how are these prices set?

Participants in the electrical market

Earlier, we discussed the fact that ISOs and RTOs coordinate the activities of everyone involved in the supply and transmission of power within their jurisdiction. But who are these entities, and how do they work together to create a market where electrical power can be bought, delivered, and sold to customers?

There are a number of participants in the electrical market, but they can be divided into generators, transmission entities, regulatory agencies and customers.

15 Basic Electricity, p. 3-40.

Generators

When you think of electric company, the two things that probably come into your mind first are power plants and electrical lines (though we could probably add your electrical bill as a third item). Many times, the same company that owns the equipment to generate electricity also owns the transmission lines, but this is not always the case, which is why we discuss generators separately from transmission entities.

The majority of the United States' electrical customers are served by investor-owned utilities (IOUs).[16] IOUs are owned by their shareholders, and their shares are sometimes bought and sold on stock exchanges like the New York Stock Exchange. In Oklahoma, the two largest investor-owned utilities are Oklahoma Gas and Electric (OG&E) and American Electric Power – Public Service Company of Oklahoma (AEP-PSO). Traditionally, IOUs own both a large fleet of electrical generators and transmission lines. While this is still the case for OG&E and AEP-PSO, these companies may also enter into contracts with other companies who own generators to provide power (see the discussion regarding merchant generators below).

Rural Electrical Cooperatives (RECs) are another important type of generator, particularly in Oklahoma. As the electrical industry was constructing generators and transmission lines in the early part of the 20th century, many rural areas were being left without service. Customers in these areas were so spread out that for-profit electrical providers did not believe they could be profitable. As a result, these customers joined together and formed their own customer-owned utilities, facilitated by loans authorized under the Rural Electrification Act.[17] Customers buy in to the cooperative by purchasing electrical service from it, and if the cooperative takes in revenues above its costs, those earnings are re-distributed to the members in proportion to their patronage (i.e. the volume of business they did with the cooperative). Oklahoma's largest generating cooperative is Western Farmers Electric Cooperative (WFEC). Nationally, electric cooperatives serve 12 percent of electric customers.[18]

Municipal utilities also play a role in generating electricity. Usually, municipal utilities are tasked with providing power to the residents of a particular town or specific area. Municipal utilities may generate their own power, but they often purchase it from another generator. In Oklahoma, many municipal utilities purchase their power from the Oklahoma Municipal Power Authority (OMPA). The OMPA is unique in that it functions as both a state agency and as a generating utility owned by its member municipal utilities. These utilities supply about 14 percent of U.S. customers.[19]

Federal power agencies are another type of generator. These agencies market the electrical power produced by federal assets (most commonly, hydroelectric dams). For example, one of the most famous federal generation assets is Hoover Dam. Hoover Dam is a hydroelectric power plant located in Nevada that is powered by the water stored in Lake Mead, which was formed by damming the Colorado River. The dam and its hydroelectric generation equipment are owned and operated by the federal Bureau of Reclamation. The power from the hydroelectric generator is then marketed through a federal power agency – the Western Area Power Administration (WAPA) – to a number of municipalities in Nevada, Arizona and California.

Merchant generators and independent power producers (IPPs) are entities that are not part of a utility but instead generate electrical power to sell to utilities. They may build their own generator facilities or buy facilities from other entities. The primary difference between merchant generators and IPPs is merchant generators frequently sell their power to a number of utilities based on current market prices, while IPPs generally enter into long-term contracts to sell power to one or a few utilities at a set price.

Transmission entities

The ownership of transmission and distribution lines may be divided in a number of dif-

16 Understanding Todays' Electrical Business, p. 85, citing data from the American Public Power Association 2009-10 Annual Directory and Statistical Report.

17 7 U.S.C. §§ 902 – 918a.

18 Understanding Today's Electrical Business, p. 87.

19 Understanding Today's Electrical Business, p. 86.

ferent ways. Many times, the same entity that owns the generators will also own transmission and distribution lines. This is how many OG&E and AEP-PSO customers are served. In other cases, utilities may own only generators and transmission lines, and then another utility will own local distribution lines. For example, WFEC owns generators and transmission lines, and then sells power to local distribution cooperatives that own and operate the local distribution lines.

Increasingly, though, there are companies that do not own any generators but focus solely on building and operating transmission lines. These companies are sometimes called transmission companies or transcos. These entities contract with utilities to provide access to their transmission lines. They also can contract with ISOs and RTOs to build transmission capacity for the grid. In Oklahoma, transmission companies can be given public utility status.[20] In the future, transmission entities may play a larger role in providing transmission infrastructure.

Regulatory agencies

No discussion of the electrical industry's structure would be complete without a discussion of how it is regulated. At the federal level, the Federal Energy Regulatory Commission (FERC) has jurisdiction over the interstate transmission of electrical power. This means FERC governs many aspects of the electrical generation and transmission process for many IOUs, merchant generators, IPPs and transmission entities. FERC also oversees many facets of ISO and RTO operations. In short, if an entity contemplates building a new electrical generation project or transmission project, it is likely FERC will be involved at some stage.

At the state level, much of Oklahoma's electrical industry is regulated by the Oklahoma Corporation Commission's (OCC) Public Utility Division (PUD). The OCC is charged with regulating the operation of IOUs in Oklahoma. However, it does not have jurisdiction over generation and transmission cooperatives or municipal utilities that are part of the OMPA.

While FERC and OCC handle many of the regulatory issues governing the generation, transmission and sale of power, there can be a number of other agencies that deal with issues impacting the electrical industry. For example, since many electrical projects will have environmental impacts, agencies like the federal Environmental Protection Agency (EPA) and the Oklahoma Department of Environmental Quality (ODEQ) may become involved. For example, although it is not strictly an electrical utility statute, the Clean Air Act and its regulations have significant impacts on what fuel sources are and will be used in generating electrical power. In areas with endangered species of plants and animals, the U.S. Fish and Wildlife Service (FWS) or the Oklahoma Department of Wildlife Conservation (ODWC) may be involved as well.

In addition to these agencies, there are also a large number of laws that impact the structure and operation of the electrical industry. Two of these are particularly important to our discussion. The first, the Public Utilities Holding Company Act (PUHCA) limited the types of businesses in which electrical utility holding companies could participate and largely limited utilities to operations within a state. Although PUHCA was repealed by the 2005 Energy Policy Act,[21] its effects on the electrical industry's structure are still visible.

Another important law for the electrical industry, and particularly for the wind industry, is the Public Utilities Regulatory Policies Act of 1978 (PURPA). Among many other provisions, PURPA requires electrical utilities to purchase energy from qualified facilities at the avoided cost of that electricity. Qualifying facilities include many cogeneration facilities and renewable energy facilities such as wind energy projects.[22] Avoided cost (also called incremental cost) is defined as what it would cost the electrical utility to generate the amount of power generated by the qualifying facility.[23] While the

20 A public utility is defined by 17 OKLA. STAT. §§ 151. For example, Plains and Eastern Clean Line Oklahoma LLC, (Plains and Eastern), a transmission-only company, was given public utility status in 2010 by the Oklahoma Corporation Commission. OCC Joint Stipulation and Settlement Agreement, OCC Cause No. PUD 201000075.

21 Pub. L. 109-58, § 1263

22 Qualifying facility was the term originally used under PURPA. With the amendments made to PURPA by the Energy Policy Act of 2005, this term has been replaced with qualifying small power production facility or cogeneration facility. See 16 U.S.C. § 796(17)(C)

23 16 U.S.C. § 824a-3(d).

PURPA rules requiring the purchase of power from qualifying facilities were relaxed, PURPA remains important to the relationship of many generators and the electrical markets.[24]

Customers

Of course, there would be little need for any of the other players in the electrical markets if there were not customers in need of electrical power. These customers can be even more varied than the sources of power that supply them. Electrical customers are often divided into industrial, commercial, and residential classes.

On a per-customer basis, industrial customers are the largest users of electrical power. While your electrical bill is often denominated in kilowatt-hours (kWh), industrial customers' bills may be denominated in megawatt-hours (MWh). The large volume of electrical power used by industrial facilities may require the facility to have specialized equipment such as large transformers, capacitor banks and generators. This equipment helps prevent disruptions to surrounding customers; without it, other customers could experience brownouts or voltage spikes when the facility turns equipment on or off. Because of the volume of electricity they use, industrial customers often have different service terms than other customers. For example, they may receive discounts on the cost of power because they buy in bulk and thus get prices closer to wholesale than retail power. Since they also have much of their own electrical equipment (such as their own substations) they cost less to serve. Since they use so much power, they may also have arrangements with the utility to reduce their power usage in high demand times, and may receive discounts for agreeing to do so. In Oklahoma, the average industrial power cost is 5.21¢/kWh.[25]

Commercial customers use less energy per customer than industrial facilities, but as a group, they use more electricity. Commercial facilities include locations like large retail stores, schools, hospitals and other businesses. They may receive power at higher voltages than retail customers and may have special equipment to manage that power. However, this equipment is not as extensive as that used in industrial facilities. They also may have an agreement with the utility to reduce electrical use during heavy demand periods, and may receive discounts for doing so. Again, because of the volume of their electrical consumption and their arrangements with the utilities, they pay slightly less for power than residential customers, but more than industrial customers. The average Oklahoma electricity price for commercial customers is 7.08 ¢/kWh.[26]

Residential customers far outnumber both industrial and commercial customers combined, with 124 million residential customers in the United States.[27] Although each residential customer uses a fraction of what an industrial or commercial customer would use, residential customers as a class account for 37 percent of U.S. electrical demand.[28] Even though residential customers use only small amounts of power, they also are expensive to serve because the utility must provide more equipment per customer than it must provide for industrial or commercial customers, and must have a much more intricate distribution network for them. Residential customers also may be less equipped to deal with disruptions in service; they are less likely than industrial or commercial customers to have backup equipment such as battery banks or generators. In Oklahoma, the average residential price for energy is 8.42 ¢/kWh. It should be noted that on average, Oklahomans pay less for their electricity than any neighboring state, and have the 8th-lowest average residential price in the entire United States.[29]

Until recently, residential customers did not have the option of receiving discounts for managing their electrical use during high demand periods like industrial or commercial customers, but with the introduction of smart grid technology in some areas this is changing. Now some residential customers can pay for their power based on when it is used (i.e. power used during peak demand times is more

24 See generally 16 U.S.C. § 824a-3(m)

25 U.S. Energy Information Administration Data for December, 2011, available at http://www.eia.gov/state/state-energy-profiles-data.cfm?sid=OK#Prices

26 U.S. Energy Information Administration Data for December, 2011

27 Understanding Today's Electricity Business, p. 22.

28 Understanding Today's Electricity Business, p. 22.

29 U.S. Energy Information Administration Data for January, 2012, available at http://www.eia.gov/state/state-energy-profiles-more-prices.cfm.

30 For an example of this program in Oklahoma, see OG&E's SmartHours program at http://www.ogepet.com/programs/smarthours.aspx.

expensive than off-peak times).[30] Some systems also give customers the option of allowing the utility to control certain devices such as air conditioning to reduce demand; this may provide the customer with additional discounts.

How do electric companies price power?

Entire books could be,and have been, written about how electrical power is priced for sale to utility customers. We will not discuss the pricing of power in that level of detail here, but we can talk about some of the basic mechanisms of the power market.

Regulated markets and tariffs

First, we need to understand that although there is an electrical market it is not a perfectly-competitive market. If we allowed completely open competition, this would mean multiple utilities would each need their own generators, transmission lines and other equipment. This could actually make for a less-efficient arrangement than allowing one utility to serve all the customers in a given area and might drive costs up. On the other hand, if we allowed a utility to have a monopoly on generating and providing power in a given area, it could use its monopoly to drive up prices for customers, since those customers would have no choice but to buy the power from one utility. As a result, many states use a regulated monopoly approach. The state agency in charge of utilities (in Oklahoma, the OCC) will give one utility the exclusive right to provide power to a given service area. However, in exchange for this business, the agency has the right to regulate the terms of service for the customers in that area and to regulate the prices the utility can charge its customers.

The set of rules that govern how a utility can charge its customers is called a tariff. A tariff will include numerous rules about how the utility can pass its costs of generating electricity along to its customers and will define an amount of profit the utility is allowed to make. While there are many costs that have to be covered by the utility, two of the biggest costs are the costs of building and maintaining its generators and transmission lines, and the variable costs of fuel used to power the generators.

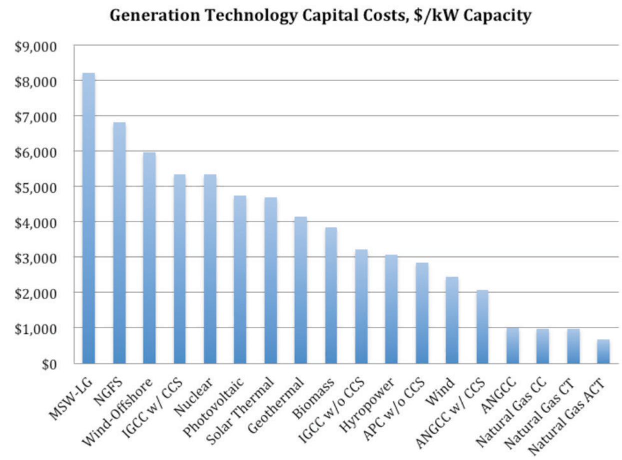


Figure 7. Capital Cost estimates for Electricity Generation Plants.

Notes:
MSW-LG: Municipal Solid Waste – Landfill Gas
NGFS: Natural Gas Fuel Cell
IGCC w/CCS: Integrated Gasification Combined Cycle Coal with Carbon Capture and Sequestration
IGCC w/o CCS: IGCC without Carbon Capture and Sequestration
APC w/o CCS: Advanced Pulverized Coal without Carbon Capture and Sequestration
ANGCC w/ CCS: Advanced Natural Gas Combined Cycle with Carbon Capture and Sequestration
ANGCC: Advanced Natural Gas Combined Cycle
Natural Gas CC: Natural Gas Combined Cycle
Natural Gas CT: Natural Gas Combustion Turbine
Natural Gas ACT: Natural Gas Advanced Combustion Turbine

Source: EIA, Annual Energy Outlook 2011 (available at http://www.eia.gov/oiaf/beck_plantcosts/)

Recovering costs

Building generating equipment can be enormously expensive, with most facilities costing hundreds of millions of dollars. To compare the costs of the different types of generators, we usually put these costs on a per-kilowatt of capacity basis. Figure 7 shows the estimated costs for building various types of generator facilities.

Given the large costs of building new generating capacity, the utility's tariff will include provisions for how the utility can pass these costs along to its customers. This is called cost recovery.

Another significant cost is the fuel used to power the generators. The cost of fuel can vary greatly over time, but a utility's customers may not be willing, or able, to deal with rapid changes in the cost of electricity. Utilities thus have to work hard to manage these fuel costs through long-term supply contracts and commodity risk-management strategies. The tariff will also include provisions for how changes in fuel prices may be passed along to customers. This is sometimes called a fuel charge.

Purchasing power from other sources

While many utilities generate a significant amount of the power they sell from their own facilities, they may also purchase power from other generators. While these transactions can be very complex, they can be divided into two basic types: long term contracts called power purchase agreements or market transactions.

Power purchase agreements

Power purchase agreements (PPAs) are long-term contracts between a utility and a generator to provide the utility with power at specified prices and terms. Since PPAs may represent a significant piece of the cost in providing a utility's customers with power, the PPA usually must be approved by the regulatory agency with authority over the utility as part of the utility's tariff. For example, if one of the Oklahoma utilities wants to enter into a PPA with another power provider, the PPA will most likely have to be approved by the OCC.

Since one of the functions of a PPA is to provide price stability to both the purchasing utility and the generator, it will contain very specific terms about how the generator will be paid. This will include provisions for the payment of things like the recovery of building and maintenance costs for the generating facility and fuel costs. In this way, PPAs resemble tariffs.

Another important feature of PPAs is their length. Typically, PPAs will last between 15 and 25 years. The reason PPAs are so long is twofold. First, this allows a sufficient length of time for the generator to recover the costs of building and maintaining their facility (or to plan for major repairs or upgrades over time). Second, it gives the utility assurance it can rely on the power provided by the generator as it plans to meet the electrical demands of its customers.

It is possible that a generating facility may have PPAs with multiple utilities. If this is the case, the PPA may have provisions defining who has priority to power if there is a high-demand period. Other generating facilities may have one PPA with one utility. A PPA that simply says the utility will buy all of the power produced by the generator is called an output contract. Many wind energy facilities have an output contract PPA with one utility.

Market transactions

Market transactions are an alternative to PPAs, and many times utilities will use both to make sure they have sufficient power to meet their customers' needs. Instead of a long-term contractual agreement to buy power, a market transaction involves the utility purchasing power in what is essentially an auction from a number of generators that have available generating capacity at a given time. This is done primarily in day-ahead and hour-ahead markets where utilities can purchase power to meet their forecasted demand in those timeframes.

While PPAs are meant to provide long-term stability of prices and electrical supply, market transaction prices can vary wildly. Generators that participate primarily in this market are taking on much greater risk than those that operate under PPAs. They accept this risk in hopes that they can capture higher prices on average than they could secure under a PPA.

How does wind fit in the electrical power industry?

We have spent some time in explaining the electrical industry from the ground up, so that you will have a foundation for understanding where wind energy fits in it. Now we are ready to take that step, and in the next chapter, you will see how wind turbines work to produce power, how that power can be used in the electrical industry, and how wind companies and utilities deal with the challenges of integrating wind into our power portfolio.

For more information

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Understanding the Wind Power Industry

Objectives

After reading this section, you will understand:

1. What is wind, and what causes it?
2. Why there is so much wind in Oklahoma?
3. How is wind measured and analyzed?
4. How has wind been used to generate power in the past?
5. How do modern wind turbines work?
6. What must wind developers consider in locating a wind energy project?
7. How do power companies use electricity from wind?
8. How do companies and individuals invest in wind energy projects?

What is wind, and what causes it?

Wind is very much a part of life for Oklahomans, so much so, that the very first line of the state song proclaims it: Oklahoma! Where the wind come sweeping down the plain… Given this, we often take the wind for granted. What exactly is wind, and why do we have it?

Wind is merely air in motion.[31] This statement from one of the early texts on wind power may seem obvious, but people sometimes miss this point. When the atmosphere is still, it is very difficult to extract energy from it to accomplish work. When it is moving, though, the energy of that motion can be captured to accomplish many things. The power of moving wind has been used for centuries, as we will discuss later. But what causes the wind? Why doesn't the atmosphere stand still?

For the most part, wind is caused by the uneven heating of the air. When air is heated, it becomes less dense. This means a cubic foot of hot air weighs less than a cubic foot of cold air. This is why hot air balloons rise; the balloon's burner makes the air inside the balloon less dense than the cool air around it. This effectively makes the balloon lighter than the air around it, causing it to float. The same effect takes place all over the earth's atmosphere. For example, let's take a sunny day in Oklahoma. The energy from the sunlight warms the soil faster than the air above it, making this air less dense. This air then begins to rise. Since, as the saying goes, nature abhors a vacuum, cooler air rushes in to fill the gap left by the rising air. This air, too, starts to warm and rise. Eventually, the air that was warmed first starts to lose its heat (because its molecules are spreading farther apart), becomes heavier, and eventually flows back towards the ground if it is surrounded by warmer air when it gets alofeet This cycle is called convection. You also can observe this cycle in a pot of boiling water. Water at the bottom of the pot, heated by the burner, becomes less dense and rises to the top, where it loses heat to the air, becomes denser, and flows back down, causing the material in the pot to move in a circular motion. The principle of convection is also what drives the towering clouds that make up many of the strong thunderstorms seen in Oklahoma and across the Great Plains.

While the process we have described drives local winds, there also are larger weather systems. The constant uneven heating of areas of the ocean versus continents gives rise to winds. So, too, warm air from the tropics collides with cool air from the polar regions. This constant mixing is critical to life on earth. Without it, the areas around the equator would be unbearably hot, and the areas farther from

31 Paul Gipe, Wind Power: Renewable Energy for Home, Farm and Business, 29 (Chelsea Green Publishing, 2004), quoting E.W. Golding, The Generation of Electricity by Wind Power.

the equator would be unbearably cold. Similarly, the winds caused by these systems could not carry moisture from the oceans to provide moisture in the form of rain and snow to inland areas. Thus, wind is not only useful for providing energy, it is vital for life on Earth.

Why is there so much wind in Oklahoma?

It is all about geography. Oklahoma has always been noted for windiness, and yet our wind is inconsistent over time and space. Physical and human geography together play a large role in the development of the wind resource. We have to understand a complicated and mix of geographic factors in order to understand wind and its use as an electrical power generation source.

Oklahoma's relative windiness is the result of its location in North America. As we mentioned above, wind is produced by pressure differences in the atmosphere. Near Earth's surface, wind blows from higher to lower pressure with deviations off a direct route caused by rotation of the Earth and the varying roughness of Earth's surface. Oklahoma is far enough south so that the greater heating of its land surface compared to Gulf of Mexico lowers pressures and causes summer air to flow into the state. Oklahoma is far enough north that the jet stream is nearby or overhead many times during the year. The jet stream divides polar and tropical air to cause surface weather disturbances with accompanying winds over the Great Plains.

Landscape geography comes into play as there are no mountain ranges north or south of us capable of preventing the wind from entering the state. Oklahoma has many hours a year when wind turbines can produce significant electricity, but the amount varies greatly even on hourly bases. Daytime tends to be windier than nighttime and spring is the windiest season.

Wind usually blows faster with altitude away from Earth's surface rather than near the surface because of the significant lessening of the effect of surface-caused friction with altitude. Even in the first few hundred feet there is a noticeable increase of wind speed. So, utility-scale wind turbines have become very large and have hubs into which the blades are attached 300 feet or more above the ground. This allows them to tap into winds that may be a third or more greater than near the surface. Smaller turbines such as used for homes or schools do not have such tall hub heights and cannot produce as much electricity per each foot of blade.

Oklahoma has one of the greatest wind resources in the United States, but it is not nearly identical all over the state. The wind is higher for more hours a year in western Oklahoma rather than eastern Oklahoma. So, wind farms first developed in western Oklahoma where the return on wind farm investment can be paid back more quickly. Even in western Oklahoma the wind doesn't blow equally well all over the landscape. High ground and ridges have more wind than the low ground surrounding them and this makes a large difference for investors as the generation produced might exceed the lowlands by 20 percent. Some areas on high ground locally have better wind. Developers always conduct wind modeling studies to determine the best placement of individual turbines. Areas of significant trees or shrubs are always avoided because these vegetation types significantly slow the air because of the greater friction compared to a bare or grassed landscape.

How is wind measured and analyzed?

Before we talk about measuring the wind, we need to talk about units for a moment. The units used to measure wind speed can often be confusing. In the U.S., we are accustomed to English (sometimes called Imperial) units, and for length, these units are the foot or mile. Thus, when it comes to speed (distance divided by time), we most commonly think of miles per hour or MPH. However, since much of the information about wind comes from scientific literature, it is put in terms of the metric system, where speed is presented in meters per second. Thus, the following table can help you approximate between the two (Table 7).

Table 7. Velocity Conversions.

MPH to m/s		*m/s to MPH*	
MPH	*m/s*	*m/s*	*MPH*
1	0.45	1	2.24
2	0.89	2	4.47
3	1.34	3	6.71
4	1.79	4	8.95
5	2.24	5	11.18
10	4.47	6	13.42
15	6.71	7	15.66
20	8.94	8	17.90
25	11.18	9	20.13
30	13.41	10	22.37
40	17.88	15	33.55
50	22.35	20	44.74
60	26.82	30	67.11

We often look at wind as a feature of the weather (rather than a resource), and as such, we use scales to help us measure the intensity of wind based on its capacity to either ruin our picnic or destroy our homes. One of the first common scales of wind intensity was the Beaufort Scale (Table 8).

As you've probably noticed, though, this scale is targeted at winds on the oceans (and note, if you've ever heard of someone talk about something destructive as a Force 12 you now know the origin of that term). In Oklahoma, we're more accustomed to a scale for winds that are even more devastating – the Enhanced Fujita Scale used to measure the intensity of tornadoes (Table 9).

Today, though, we recognize wind can be an important source of energy, and so we care about another scale of wind measurement. We now look at the class of wind energy (Table 10).

So, how do we measure wind? The most common tool used is an anemometer. An anemometer uses a propeller on either a vertical or horizontal axis (Figure 8). Usually, the anemometer measures wind speed by using an electrical circuit inside the propeller; as the propeller turns it causes impulses in the circuit which are counted over time to determine how fast the wind blows.

When a research institution, wind developer or landowner want to record detailed information about wind speed and direction over time, they will often use a meteorological data tower,

Table 8. Beaufort Scale of Wind Force.

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
			On the Water	On Land
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft, whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-19 ft, white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (18-25 ft) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Twigs breaking off trees, generally impedes progress
9	41-47	Strong Gale	High waves (23-32 ft), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (29-41 ft) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (37-52 ft) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft, sea completely white with driving spray, visibility greatly reduced	

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/faq/tornado/beaufort.html

Table 9. Enhanced Fujita Scale.

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	**EF Number**	**3 Second Gust (mph)**
0	40-72	45-78	0	65-85	**0**	**65-85**
1	73-112	79-117	1	86-109	**1**	**86-110**
2	113-157	118-161	2	110-137	**2**	**111-135**
3	158-207	162-209	3	138-167	**3**	**136-165**
4	208-260	210-261	4	168-199	**4**	**166-200**
5	261-318	262-317	5	200-234	**5**	**Over 200**

Source: NOAA Storm Prediction Center, http://www.spc.noaa.gov/efscale/ef-scale.html

Table 10. NREL Wind Energy Classes.

Wind Power Class*	**10 m (33 ft)**		**50 m (164 ft)**	
	Wind Power Density (W/m²)	**Speed(b) m/s (mph)**	**Wind Power Density (W/m²)**	**Speed(b) m/s (mph)**
1	0	0	0	0
2	100	4.4 (9.8)	200	5.6 (12.5)
3	150	5.1 (11.5)	300	6.4 (14.3)
4	200	5.6 (12.5)	400	7.0 (15.7)
5	250	6.0 (13.4)	500	7.5 (16.8)
6	300	6.4 (14.3)	600	8.0 (17.9)
7	400	7.0 (15.7)	800	8.8 (19.7)
	1000	9.4 (21.1)	2000	11.9 (26.6)

Image from National Renewable Energy Laboratory, http://rredc.nrel.gov/wind/pubs/atlas/tables/1-1T.html

Figure 8. Example of a vertical-axis anemometer (left) and horizontal-axis anemometer (right)
Source: Vertical axis anemometer, NRG Systems, www.nrgsystems.com; horizontal-axis anemometer, Kestrel Meters, www.kestrelmeters.com

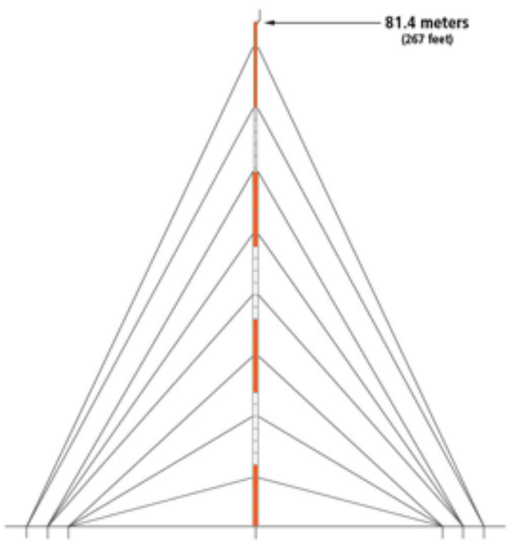

Figure 9. Example of a met tower.
Source: NRG Systems, http://www.nrgsystems.com

Figure 10. Example of a met tower data logger.
Image from http://www.nrgsystems.com

or met tower (Figure 9). Typically, a met tower will be a guyed tower (held upright by a series of wires anchored to the ground) with a series of anemometers and wind vanes at various heights.

The tower will also have a logger (Figure 10) which is a small computer that records the data gathered by the anemometers and wind vanes. In some cases, the logger will record the data on chips that must be collected and returned for analysis, but increasingly, loggers use cellular phone modems to transmit data directly to an analysis center.

Another tool growing in use is Light Detection and Ranging or LIDAR which uses a sensor to measure the reflection of a laser beam on atmospheric particles to determine wind speeds in an area (Figure 11).

Figure 11. Examples of LIDAR system.
Source: QinetiQ, www.quinetiq.com

The developer or anyone else thinking about installing large wind turbines will need to collect at least a year's worth of data for a site. This is needed to understand not only the wind speeds, but also how they vary over the seasons of the year. Many wind project investors and banks also insist on having at least a year of data before they will fund a project. Noting that someone has placed a met tower in the area is an important signal they are serious about exploring the possibility of wind energy development in the area. While individual landowners may be able to get small-scale wind logging equipment through a loan program for little expense, the scale of measurement required for a commercial wind farm can cost more than $100,000.[32] Part of the reason this is so expensive is the developer will need to get data on the winds at the height above ground where the turbines will be, not at the surface. This makes data collection more difficult as it requires either much taller met towers or the LIDAR systems mentioned above. Fortunately, landowners desiring installation of small turbines do not need detailed wind studies because Oklahoma has already been assessed by statewide maps showing model-estimated wind power at a fine scale.

While someone thinking about installing a turbine will want to acquire data on that specific site, government agencies have acquired a significant amount of information on a larger

32 Erich Hau, Windturbines, 585 (Springer, 2000)

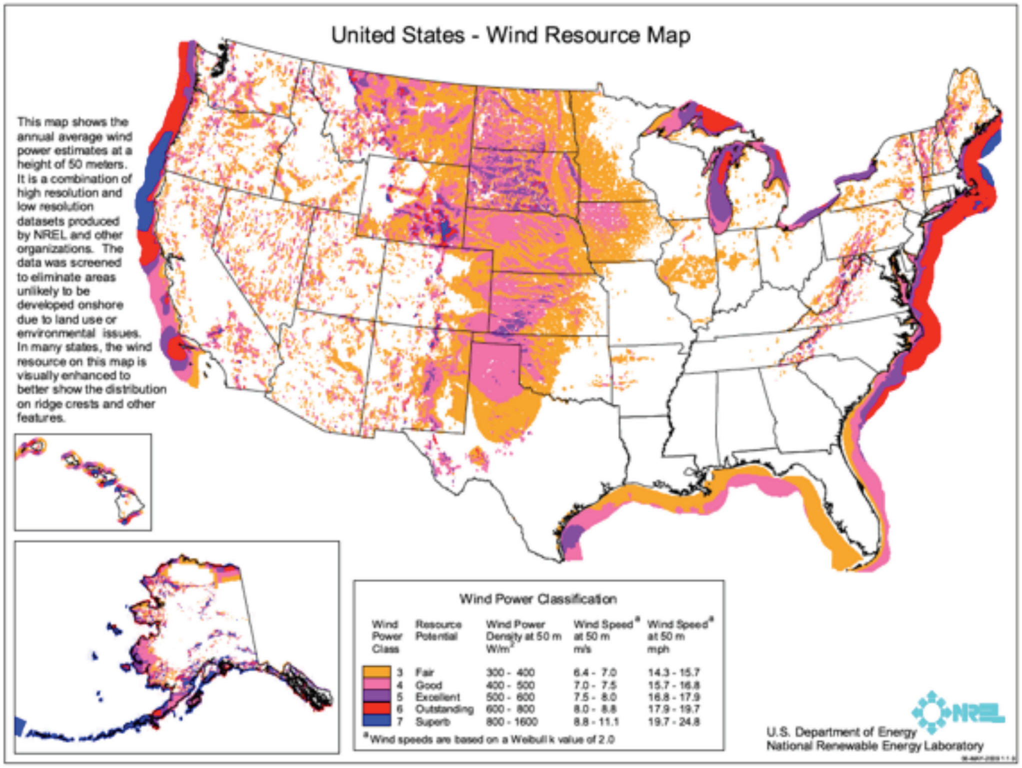

Figure 12. U.S. Wind Energy Resource Map.

Source: National Renewable Energy Laboratory, http://www.nrel.gov/gis/pdfs/windsmodel-4pub1-1-9base200904enh.pdf

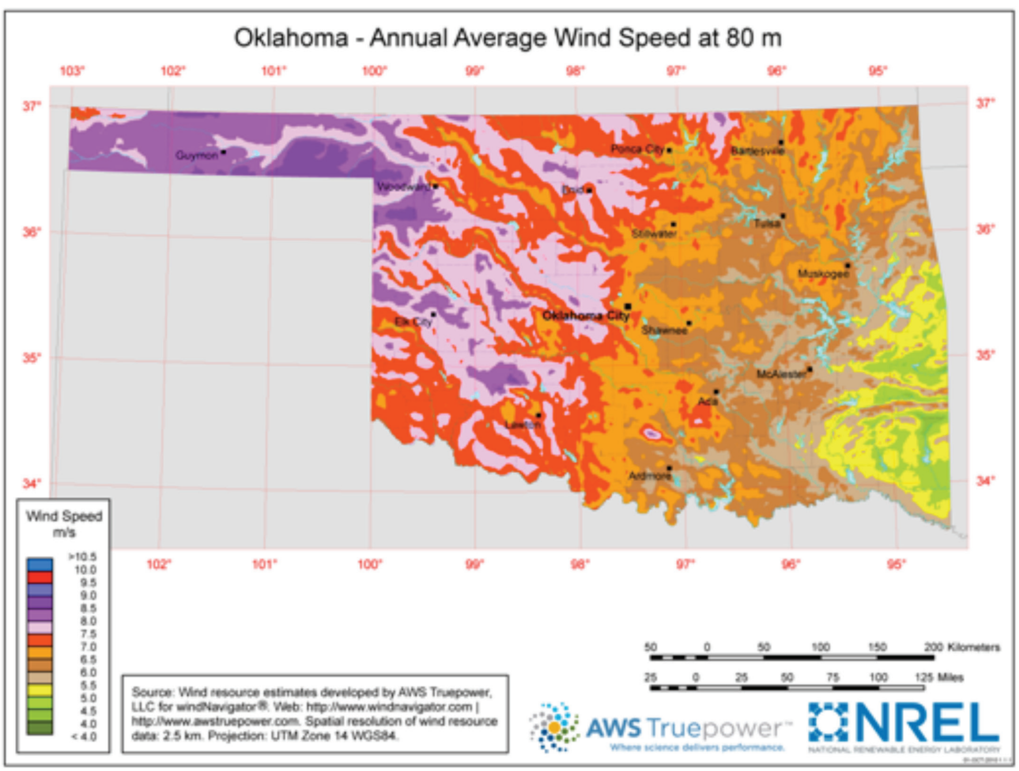

Figure 13. Oklahoma Average Wind Speed at 80m (262 ft).

Source: National Renewable Energy Laboratory, http://www.nrel.gov/gis/images/80m_wind/awstpspd80on1-1dpi600OK.jpg scale, and have compiled wind energy resource maps for the nation and individual states. Figure 12 shows the wind energy resource for the United States.

A closer view of the wind energy potential for Oklahoma is included in Figure 13.

How has wind been used to generate power in the past?

Along with fire and moving water, wind was one of the first of nature's forces to be harnessed by man. Scholars believe the first clearly-defined use of the wind was by the Egyptian boats on the Nile River using cloth or papyrus sails around 3100 B.C.[33] Indeed, the use of wind to propel ships would shape the world through its use in the Greek, Roman, Spanish and British empires.

Wind was not just used on the water, though. Several centuries after the invention of the sail, vertical-axis windmills (windmills rotating around a vertical line, like a carousel) in Persia began to grind rain and lift water out of streams for irrigation in the 10th century A.D.[34] The English post-windmill, a horizontal-axis windmill (a windmill rotating around a line parallel to the horizon) began to work on similar tasks in 1137 A.D.[35] Windmills then began to change the European landscape, and in some cases even created new portions of Europe with a series of windmills working together to help the Dutch pump water out of lowlands, effectively creating large new areas of cropland.[36]

In America, the wind was a vital force in the settlement of the West. At least one historian has argued three inventions were crucial to the settlement of the Great Plains: barbed wire, the six-shooter and the windmill.[37] In at least one case, pioneers even used wagons fitted with sails to propel them westward.[38] The greatest advantage provided by wind, though, was the use of windmills for pumping water from its deep aquifers to make productive land out of plains that might not see settlement otherwise.[39]

It may surprise many people that the first use of windmills to generate electricity occurred at almost the same time, with limited commercial sales of windmills designed for residential electric generation in the 1890s.[40] In the early part of the 20th century, these first generations of electric wind turbines provided power to many rural homesteads who could not get power otherwise as they were too remote to be profitable for utilities or to even take advantage of the programs of the Rural Electrification Administration (REA).[41]

As the REA and rural electric cooperatives gradually reached most rural customers and household power demands became much larger, the importance of wind for electrical generation in the U.S. decreased. However, during this same time, wind energy was still growing in Europe, particularly in Denmark and Germany where many European manufacturers were, and still are, important suppliers of wind turbine equipment.[42] It was only with the energy crisis of the 1970s and early 1980s that would revive interest in North American wind energy.

Several scholars consider California in the early 1980s, to be the birthplace of the modern American wind energy industry.[43] Its market for electrical power, availability of transmission capacity near dense wind resources, and energy policies made California the leading state in U.S. wind energy until 2006.[44] In the mid- to late 1990s, the deregulation of electrical markets, dramatic improvements in turbine efficiency and increasing instability in natural gas prices led power companies and investors nationwide to look at wind once more. With unprecedented growth, wind quickly overtook every other renewable resource except for hydroelectric power, as illustrated in Figure 14.

33 Robert Righter, Wind Energy in America: A History, 6. (University of Oklahoma Press, 1996).
34 Righter, 7.
35 Righter, 10.
36 Righter, 17.
37 Righter, 23.
38 Righter, 22.
39 See Dick Hays & Bill Allen, Windmills and Pumps of the Southwest, 2 (Eakin Press 1983).
40 See T. Lindsay Baker, A Field Guide to American Windmills 45 (University of Oklahoma Press, 1985).
41 Righter, 99.
42 Paul Gipe, Wind Energy Basics: A Guide to Home- and Community-Scale Wind Energy Systems, 2d Ed. (Chelsea Green, 2009), 91.
43 See, e.g. Gipe, xv, 91, 93.
44 See Manwell, J.F., McGowan, J.G., and Rogers, A.L., 2002. Wind energy explained: theory, design and application. Wiley, West Sussex. See also Gipe, 91.

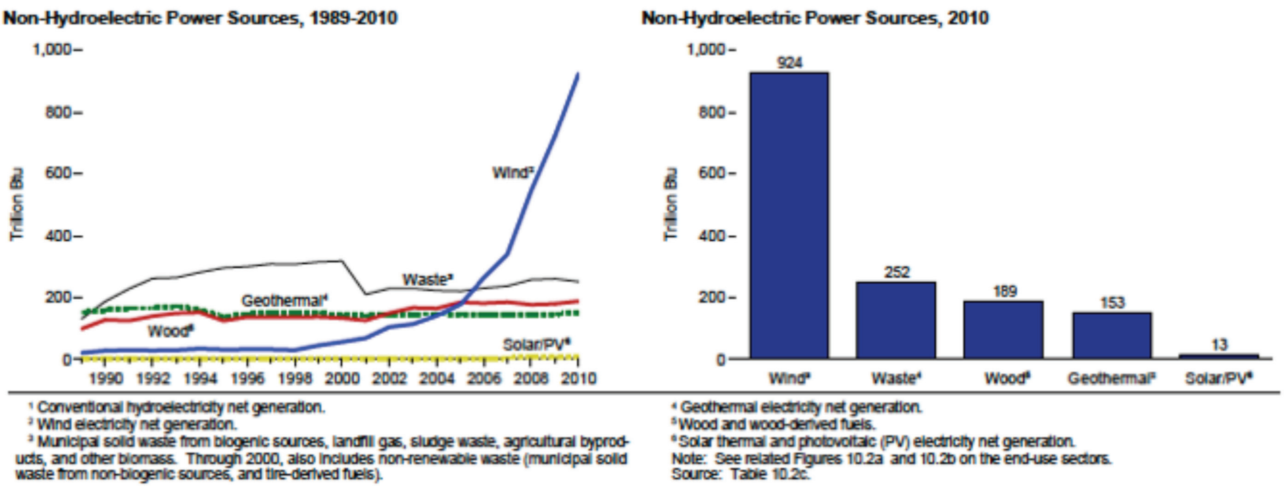

Figure 14. Historical Trends in Use of Renewable Resources.
Source: Energy Information Administration (EIA), http://www.eia.gov/emeu/aer/pdf/pages/sec10.pdf

While California was the leader in U.S. wind energy until 2006, Texas would overtake it and move on to a commanding lead, with approximately three times the installed capacity of California at the end of 2011.[45] Much of Texas' explosive growth may be attributed to the fortunate circumstance that one of its largest and most dense wind resource areas is bisected by one of its largest electrical transmission lines.[46] Aggressive state programs to build transmission capacity in areas most likely to stimulate wind power development also attracted development. Similarly, access to transmission and a supportive policy environment have helped Iowa overtake California to become the second largest wind power state in the U.S. The top ten states in terms of installed wind power capacity are shown in Figure 15.

Oklahoma has experienced significant and rapid growth of its own wind energy industry. While the state had no utility-scale wind power at the start of 2002, it has now grown to have more than 2,000 megawatts of capacity, with more still under construction (Figure 16). This growth is more impressive given that Oklahoma has the lowest retail price of electricity of all its neighboring states and historically lacked any

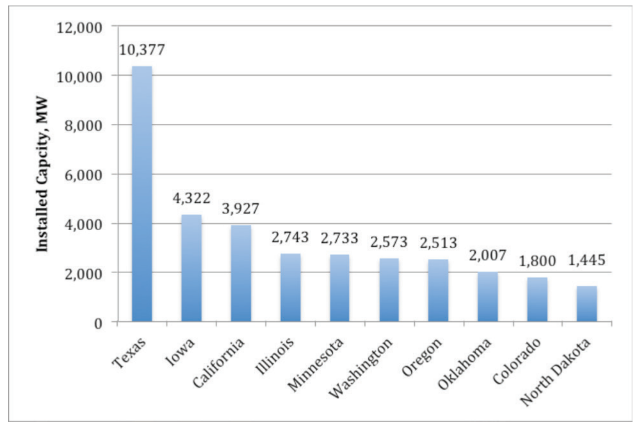

Figure 15. Top Ten U.S. States by Installed Wind Energy Capacity, 2012.
Source: USDOE, Office of Energy Efficiency and Renewable Energy, http://www.windpoweringamerica.gov/wind_installed_capacity.asp

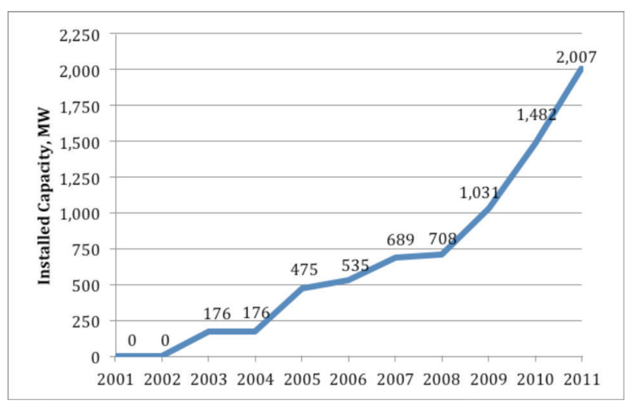

Figure 16. Oklahoma's Installed Wind Energy Capacity (EERE, 2012).
Source: USDOE Office of Energy Efficiency and Renewable Energy, http://www.windpoweringamerica.gov/wind_installed_capacity.asp

45 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2012. U.S. installed wind energy capacity. Retrieved from http://www.windpoweringamerica.gov/wind_installed_capacity.asp, last visited May 2, 2012.

46 Smith, E., DeWolf, S., Wetsel, R., 2011. Texas Wind Law. Matthew Bender, New Providence.

robust state policies specifically targeted at the development of renewable resources, with the exception of a modest tax credit for zero-emission electrical power sources. In comparison, every other state with more installed wind energy capacity than Oklahoma (as of the end of 2011) had at least an enforceable Renewable Portfolio Standard (RPS) and other incentives for wind energy development.[47]

While the growth of the wind power industry is impressive, the remaining potential of the industry far exceeds its current size. If the goal of 20 percent wind energy by 2030 is met, U.S. wind energy installations would have to reach more than 300,000 megawatts, or more than six times its current capacity of 48,611 megawatts.[48] At the present rate of installation that goal will be met with Oklahoma being the second-largest producer of wind energy in the United States. Regardless of whether such growth is achieved, even the current pace of growth in the industry brings challenges for policymakers and landowners.

The U.S. wind energy industry has seen explosive growth over the past decade, with national installed capacity growing from 2,377 megawatts in 2001 to 43,461 megawatts at the end of 2011.[49] 2009 was the year that saw the biggest single year growth, with 9,645 megawatts of capacity installed.[50] Although, at the time of this writing, the debate over the extension of what is regarded by many as the industry's most important subsidy has caused concern regarding whether this pace can be sustained.[51] There remains a large number of wind energy projects at various states in the development pipeline, with 8,400 megawatts of capacity under construction at the time of this writing.[52]

How do modern wind turbines work?

In some ways, the windmill that may pump water for your livestock and the wind turbine that generates electrical power for hundreds of homes work the same. They both convert the energy of the wind moving over their blades to accomplish mechanical work. They share other similarities, but also have many differences. Let's take a look at the typical design of a modern wind turbine (Figure 17).

Virtually all U.S. wind turbines (and most utility-scale turbines around the world) use three blades to convert the straight-line energy of the wind into rotational (circular) energy. The blades are often constructed of fiberglass or other composites and are quite large, with

47 Oklahoma has an aspirational RPS with desired targets for renewable energy use by utilities operating in the state, but those targets are not enforceable (17 Okla. Stat. § 801.4). It also has a sales tax exemption for wind energy facilities and a modest wind energy tax credit (68 Okla. Stat. § 2357.32A). As a contrasting example, Texas has an enforceable RPS, franchise tax exemptions for wind energy enterprises, and the Competitive Renewable Energy Zone (CREZ) program to encourage the construction of electrical transmission systems in areas with high wind energy resources. Beyond Texas, the other states with more installed wind energy capacity than Oklahoma (Iowa, California, Illinois, Minnesota, Washington, and Oregon employ a number of policies to encourage wind energy development. These policies cover a wide range, including RPSs (mandatory in each of these states), sales tax exemptions, special assessment of wind energy facilities for property taxes, public grant funding for project development, production incentive payments, and requirements that utilities provide customers with green power purchasing options. (DSIRE, 2012).

48 U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), 2008a. 20% wind energy by 2030: increasing wind energy's contribution to U.S. electricity supply. Retrieved from http://www1.eere.energy.gov/windandhydro/wind_2030.html, last visited June 22, 2011. See also American Wind Energy Association (AWEA), 2012. 2012 first quarter installed U.S. capacity, 1. Retrieved from http://www.awea.org/learnabout/industry_stats/index.cfm, last visited June 6, 2012.

49 U.S. Energy Information Administration, Wind, available at http://www.eia.gov/cneaf/solar.renewables/page/wind/wind.html (last visited January 5, 2012); American Wind Energy Association (hereinafter AWEA), U.S. Wind Industry Third Quarter Market Report, October 2011, 1, available at http://www.awea.org/learnabout/publications/reports/upload/3Q-2011-AWEA-Market-Report-for-Public-2.pdf (last visited January 5, 2012).

50 Id.

51 See, e.g. North American Wind Power Staff, Vestas President Testifies before Senate Subcommittee to Urge PTC Extension, North American Wind Power Policy Watch (Dec. 15, 2011) available at http://www.nawindpower.com/e107_plugins/content/content.php?content.9070 (last visited January 5, 2012).

52 AWEA, U.S. Wind Industry Third Quarter Market Report, October 2011, 1, available at http://www.awea.org/learnabout/publications/reports/upload/3Q-2011-AWEA-Market-Report-for-Public-2.pdf (last visited January 5, 2012).

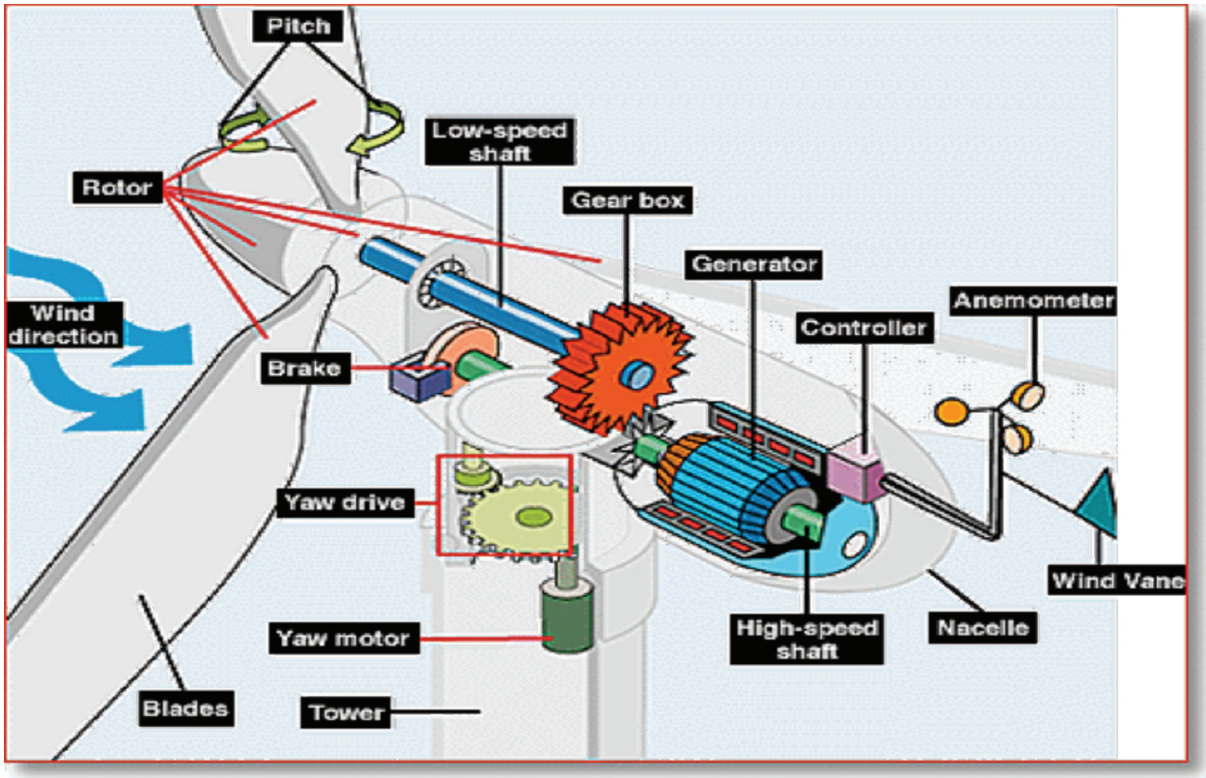

Figure 17. Wind turbine components
Image from National Renewable Energy Laboratory, http://www1.eere.energy.gov/wind/wind_how.html#inside

many of Oklahoma's turbines using blades in excess of 115 feet long, weighing nearly 10 tons. If you look at a blade, you will notice that it resembles an airplane wing. This is no coincidence, as the blade works just like a wing. Air moving over the blade causes lift, which pulls the blade along and thus moves the turbine. Modern turbines use pitch control to adjust the angle of the blade depending on the wind to maximize the lift and thus the energy the turbine can extract from the wind. Computer controls constantly make this adjustment, meaning at a given time each of the blades may have a different pitch. Along with controlling pitch, the turbine also uses its yaw motor and yaw drive to turn the turbine into the wind. Both pitch and yaw functions are adjusted by a controller which is a computer that regulates the turbine. The controller gets information from an anemometer and weather vane located on the turbine.

The blades are connected to a hub. This hub is the size of a small car and can weigh 20 tons. It must be very strong as it bears a lot of the mechanical stress caused by all the forces acting on the blades. Together, the blades and the hub make up the turbine's rotor.

A low speed shaft is the mechanical connection between the rotor and the rest of the generator equipment. This shaft is connected to a gear box or transmission. Because the rotor is so large, it can only turn at slow speeds (depending on the size of the turbine, between 10 and 60 revolutions per minute or RPMs) or else mechanical stresses would tear it apart. However, as you may remember from the chapter on electrical power, most electrical generators must turn at very high speeds to generate power suitable for the electrical grid. This is where the gear box comes in. The gear box uses a series of gears to convert the low RPMs of the rotor into the high RPMs needed to run the generator. A high-speed shaft connects the gearbox to the generator.

The generator is the device that converts the rotational mechanical energy from the shaft into electrical energy. The generator then sends the power to the base of the turbine, where its voltage may be stepped up before being sent on to a substation located at the wind energy project (refer back to the chapter on the electrical industry to learn how transformers work).

Since the turbine can be damaged if it turns too quickly, there are a number of safety devices to prevent this from happening. First, the controller can turn the blades to an angle that is perpendicular to the wind. This is sometimes called feathering and causes the blades to stall meaning the wind flowing over them can no longer generate the lift needed to make them turn. Secondly, the controller may engage a brake that uses either a hydraulically-powered disc (much like the brakes in your car) or an electromagnet to stop the rotor from turning. In a way, a typical water windmill in the U.S. achieves the same goal by furling or folding its rotors and tail section together to reduce or stop its rotation.

The large housing that contains the low- and high-speed shafts, gearbox, generator, controller, and other equipment is called the nacelle. This nacelle may be the size of a bus, and can weigh more than 50 tons.

These are the basic mechanics of the turbine, but how can we tell how much energy a turbine can generate? If you really want to understand how wind turbines work, you need to understand one equation. It may look intimidating, but don't worry, it is actually quite simple, and we will explain it step by step.

The equation that predicts how much power a turbine could generate if it were perfectly efficient is this:[54]

$$P = \frac{1}{2}\ \rho\ v^3\ \Pi r^2$$

In this equation "P" represents the power available from the wind. If you are using a wind turbine to provide power to your home, or if you are a developer looking to use towers to power several thousand homes, you want to maximize P. That means you now have to worry about "ρ" "v" and "r".

The variable ρ (the Greek rho) is the density of the air, which largely depends on a turbine's elevation (how high it is above sea level) and the air temperature. If we hold everything else constant, a turbine at sea level would generate more power than a turbine in the mountains since the air is denser at sea level. Similarly, if we hold everything constant again, a turbine will generate more power on a cold day than a hot day, since cold air is denser. The impact of ρ is relatively small compared to the other variables, though, and since we really can't do much to affect air density, we will spend more time concentrating on the other variables.

The variable v represents the velocity of the wind. While you would naturally expect a faster wind to carry more power than a slower one, the magnitude of that difference may come as a surprise. Since v is cubed (taken to the third power, or v^3), the power carried by the wind increases as a cube of its speed. In other words, if the wind speed increases from 10 miles per hour to 20 miles per hour – a doubling in speed (2x) – then the resulting increase in power is cubed (2x2x2), or eight times the power of the original wind. This means wind speed has a tremendous impact on the amount of power we can generate from the wind, which is why locating a site with an optimal range of wind is crucial in the profitability of a project. Factors such as regional geography impact average wind speeds as we discussed above, but highly localized factors such as the topography (local terrain) of the turbine site and its elevation above the ground's surface can have significant effects as well.[55] As a result, siting decisions are of paramount importance to the profitability of a wind power project and drive many wind energy agreement terms.[56] We will discuss siting issues a little later.

The second variable in the equation, r, represents the radius of a circle. If you look at the path of the turbine's blade tips as forming a circle (the circle formed by the path of the blades is sometimes called the turbine's rotor disc), then the length of a blade is the radius of that circle. As you may (or may not) remember from geometry class, the formula for the area of a circle is Πr^2. Since r (the radius) is squared, this means that the area of a circle varies as the square of its radius. In turn, that means that if we double the length of a blade (2x), that gives us gives us 2x2, or four times more area in the

54 Paul Gipe, Wind Energy Basics 7 (1999).

55 See J.F. Manwell et al, Wind Energy Explained: Theory, Design, and Applications 46-56 (2002). See also Hau, supra note 17 at 459-461. For an excellent discussion and illustrations of factors that can impact wind speeds at a turbine site, refer to the discussion Turbine Siting presented by the Danish Wind Industry Association at http://wiki.windpower.org/index.php/Category:Turbine_siting (last visited January 7, 2012).

56 See generally AWEA, Wind Energy Siting Handbook (2008), available at http://www.awea.org/sitinghandbook/downloads/AWEA_Siting_Handbook_Feb2008.pdf (last visited January 6, 2012).

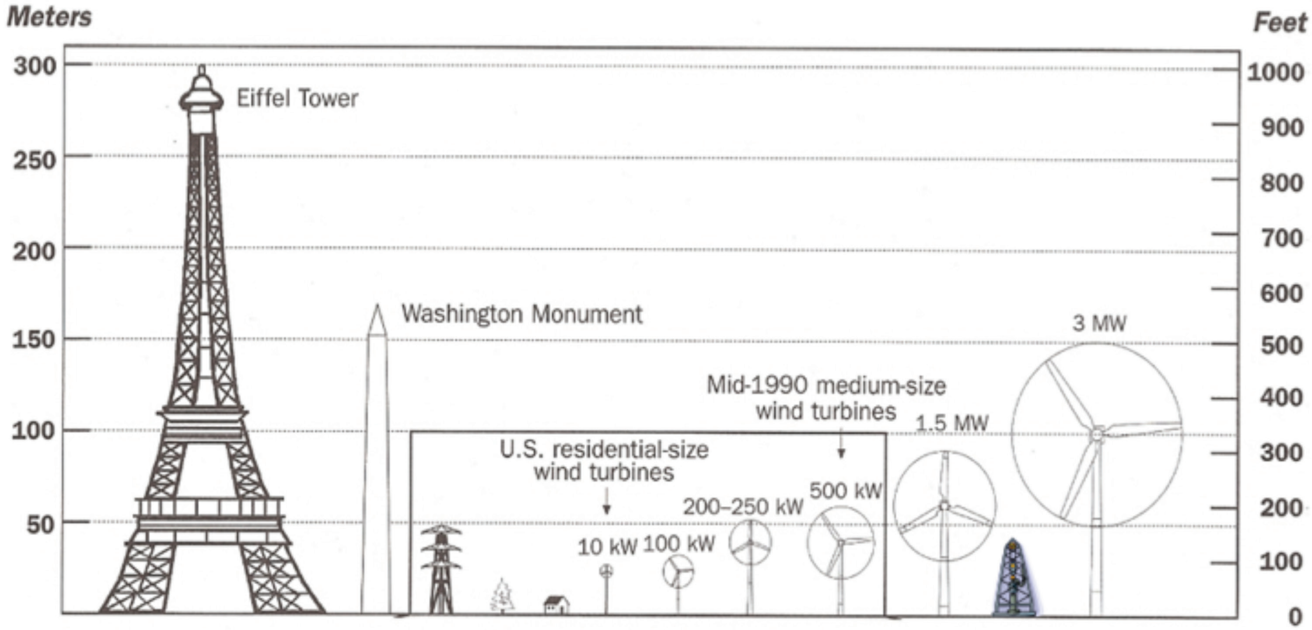

Figure 18. Turbine Scales.
Image from Paul Gipe, Wind Energy Basics, Chelsea Green Publishing, 1999

rotor disc. Since a bigger rotor disc represents the ability to capture more wind, turbine manufacturers have constantly sought means of making turbines bigger and bigger. Advances in composite materials and computer control technology in the mid-to-late 1990s made these large turbines possible, and enabled the industry to become cost-competitive with other electrical generation sources.[57] Figure 18 can give a sense of how turbines have increased in size through the years.

This means developers will tend to seek the largest affordable turbine equipment so as to maximize potential power production from a given site. This can impact the amount of power generated on a piece of land and can thus impact how much royalty can be paid to landowners. It can also impact the number of turbines that can be situated on a particular landowner's property, since turbines must be spaced apart from each other to prevent the turbines from interfering with each other.

What do wind developers consider in locating wind energy projects?

As we just discussed, wind speeds have a tremendous impact on how much energy a wind turbine can produce. This means one of the most, if not the most important factor developers consider in determining where to place a wind project is where the wind speeds will be highest.

The first things that a developer investigates are the wind resource maps discussed above. This will show the developer areas where a good wind resource can be expected. Next, the developer will see if any large utility transmission lines are available. As we discussed in the electrical industry chapter, transmission lines large enough to carry the power generated by a utility-scale wind project are very expensive. Even if an area has a tremendous wind resource and can produce vast amounts of electrical energy, the project may not be profitable if it is too far from utility lines as the added capital cost in building the lines will erase the added profits. Moreover, the existence of a nearby

57 See generally Paul Gipe, Wind Energy Basics (2d ed. 2010).

Figure 19. The Developer's Dilemma between wind resource and transmission

transmission line may be of little use if the line is already near its capacity. Thus, developers are always trying to balance a location's wind resource with its access to transmission (Figure 19). This is why, to date, an extremely windy region like the Oklahoma Panhandle does not have any wind power projects, but an area with less wind, such as Garfield County, does have a project. As a result, if you are trying to determine the potential of your property for wind energy development, first look at a wind resource map and see how much wind energy potential your land has, then see how close the land is to a large-scale transmission line.

Let's say a developer has determined an area has a good wind resource, and it is close enough to transmission to be profitable. What now? The next step will be for the developer to come up with a project layout. Here, developers face another dilemma. They want to place as many turbines as they can in a given area to

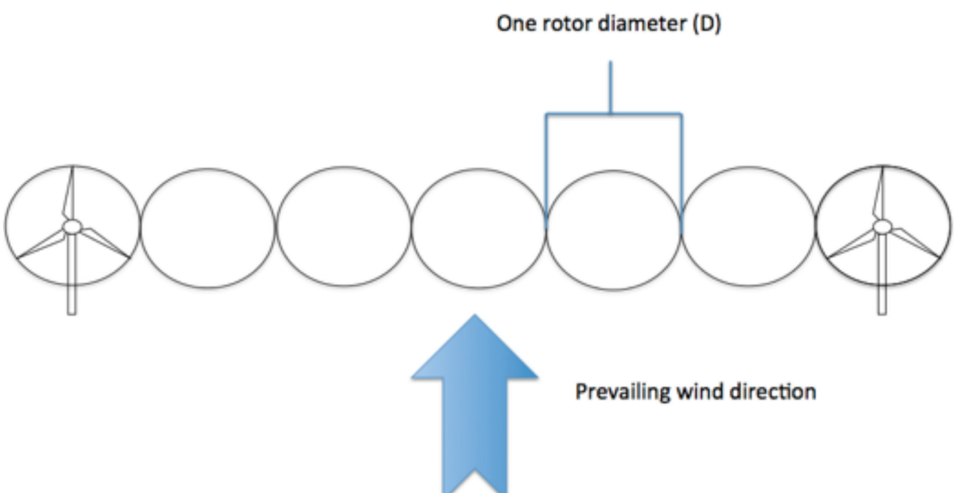

Figure 20. Diagram of turbine spacing in crosswind wind direction.

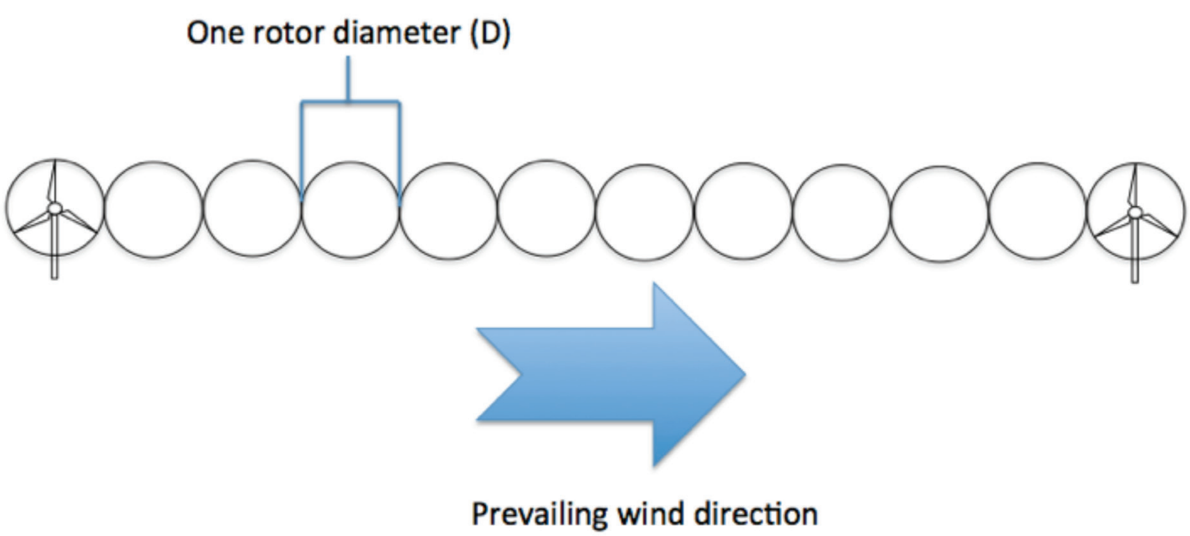

Figure 21. Diagram of wind turbine spacing in direction of prevailing wind (i.e. downwind).

maximize the power (and thus revenues) they can produce. However, developers also know that if they place turbines too close together, the turbulence they generate will cause neighboring turbines to interfere with each other and thus actually reduce the amount of power generated. For example, research has shown to reduce turbulence losses to 10 percent, turbines must be placed no closer than five rotor diameters apart in the crosswind direction, and no closer than eight to 10 rotor diameters apart in the prevailing wind direction.[58] Figures 20 and 21 illustrate this spacing. For example, if a tubine's blades are 115 feet long, then the rotor diameter is 115x2, or 230 feet. Thus, if the prevailing winds were north and south (as they tend to be in Oklahoma), the turbines would be spaced no closer than 1,150 feet going east and west, and no closer than 1,840 feet going north and south.

What does this mean for landowners? There are two implications. First, there is a limit to how many turbines can be placed on a parcel of land. The American Wind Energy Association estimates the total land use per megawatt of wind turbine capacity is 60 acres, with three acres physically occupied by the project (this is land taken up by the turbine base and pad, roads and other systems), and the remaining 57 acres used only as an unobstructed clear area to preserve wind flow to the turbine array.[59] As a practical matter for most Oklahoma projects, this means that four turbines are typically the limit for a quarter section (160 acres) of property (Figure 22).

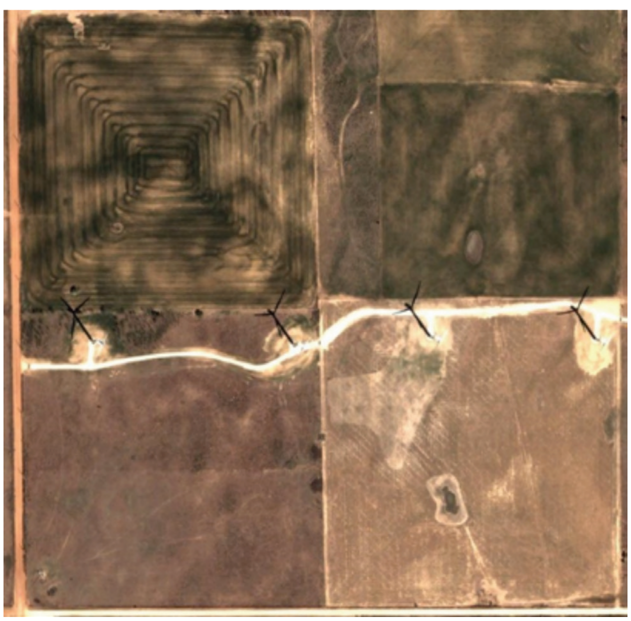

Figure 22. Aerial photo of quarter-section of property in Woodward County with four turbines (note shadows). Photo taken from Google Earth.

Turbulence doesn't just come from other turbines, though. It can come from any object near the turbine. Developers do not like to place turbines next to tall objects that can generate turbulence that would interfere with the turbine's optimal performance. The principals of aerodynamics tell us an object will cause turbulence upward in the air for a height twice that of the object. For example, if we have an oil derrick that is 140 feet tall, that derrick can cause turbulence upward 280 feet into the air. Aerodynamics also tells us an object can cause turbulence downwind for a distance of up to twenty times its height. So the same oil derrick could cause turbulence for 2,800 feet downwind – over half a mile. Note, though the farther someone gets away from the turbulence-causing object, the closer that turbulence is to the ground and the less significant it is. Finally – and this may be somewhat surprising – an object can cause turbulence for a distance up to twice its height. For our oil derrick, this means that it can cause turbulence up to 280 feet upwind of itself. Figure 23 shows these patterns.

Minimizing turbulence is the reason many agreements contain language requiring the landowner to either get permission from the developer before they construct any new structures on the property, or restricting any new structures to a certain height. Similarly, the lease might require the landowner to restrict oil and gas development on the property. We will discuss these issues in greater detail in the chapter on wind energy agreements. For now, though, it is important to note that oil derricks are not permanent; they are only in place for as long as they are needed to drill a well and then they are removed. Property can be developed for both wind and petroleum with little interference between the two, so long as both developers work cooperatively.

Beyond the mechanics of the wind turbines'

58 Manwell, supra at 385.

59 See AWEA, Wind Energy and the Environment, http://www.awea.org/faq/wwt_environment.html .

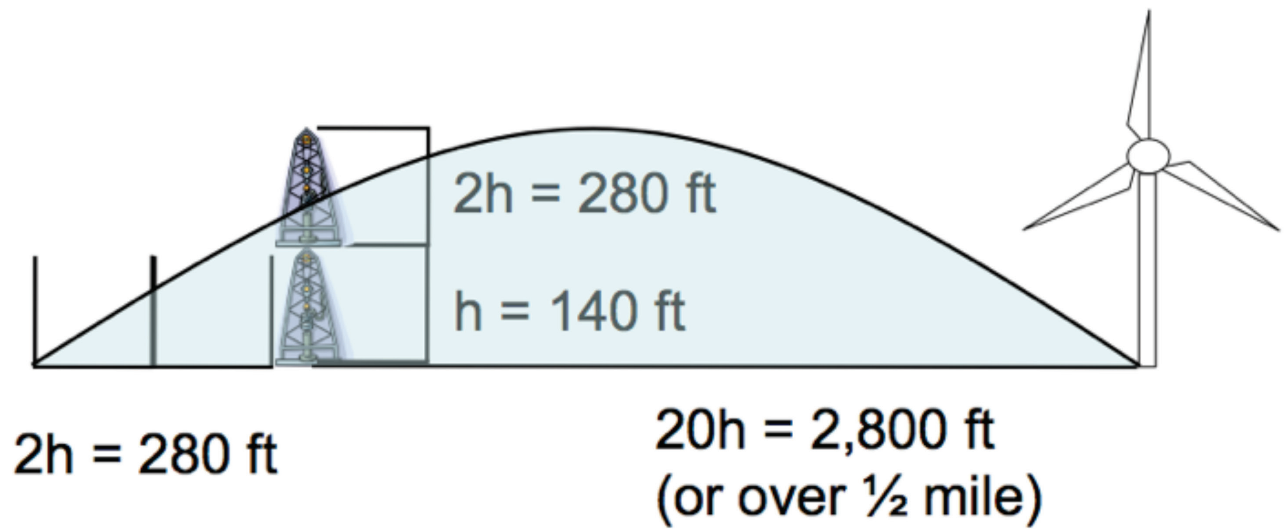

Figure 23. Example of turbulence effect distances.

layout, there are many other things that go into the configuration of the wind energy project. Developers may need to conduct wildlife studies to see if endangered species are present in the area. Construction feasibility studies, including soil sampling and surveys are also needed to see if construction equipment can reach the planned turbine sites.

How do power companies use electricity from wind?

Wind power has many advantages in that it does not require pollution-emitting fuel to generate power, wind turbines have relatively low operation and maintenance costs, and wind energy projects can be built quickly compared to other generation plants. Also, they do not produce air pollutants such as carbon dioxide and other greenhouse gases. However, wind does have a disadvantage. When the wind blows, it blows, and when it doesn't, it doesn't. This means wind energy is not dispatchable. In other words, power companies cannot ask for more wind power on a hot day when everyone turns on their electric air conditioners – they must settle for whatever wind power is available. Another side of this issue is wind power must be used when it is available, or it is lost.

As discussed in the electrical industry chapter, power companies have an obligation to make sure power is always available when customers need it. Thus, if a power company chooses to use large amounts of wind as part of its power portfolio, it must (1) have reliable predictions about both electrical demand and about how much wind will be available, and (2) access to other forms of electrical generation that can be brought online quickly if there is a loss of wind power. Generally, utilities have very good models to help them estimate how much power will be needed at a given time (these models are usually based on temperatures and thus they are also dependent on weather forecasts), and models for predicting the winds continue to improve.

Making sure power is available in case wind is not involves three potential solutions. Right now, the most frequent solution is to have a more traditional generation source available that can be brought online quickly in case the wind subsides quickly. In many cases, this is natural gas. As discussed in the electrical industry chapter, some natural gas turbine generators can be brought into operation very quickly, although these generators can be expensive to run. Since Oklahoma utilities use a great deal of natural gas generation thanks to is availability in the state, this makes wind energy a good fit for some of these utilities. Besides using other generation resources, another measure utilities can use is a broader electrical transmission network. Recent years have seen utilities group into regional grids like the Southwest Power Pool. Broader networks mean utilities can diversify their power sources, including wind. This means in the near future, if the wind subsides in Oklahoma but becomes strong in Nebraska, the utilities within the grid can shift their generation resources to still maintain a large proportion of wind, but now from a different source. The third possible solution is to make wind energy dispatchable. How is this possible? The key is to create a technology that can store large amounts of energy and release it on demand. When there was more wind power than was demanded by the grid, the energy could be stored, and when demand increased beyond the wind generation capacity, it could be released. Right now there are no such technologies, but there are promising projects looking into large-scale battery arrays, using wind to compress and store air that can be released to drive generators, and using wind to convert water into hydrogen gas that can then be burned or used in fuel cells to generate electricity.

How do companies and individuals invest in wind energy projects?

Large projects are very costly–usually exceeding $100 million dollars in Oklahoma–so individual and local financing is seldom possible. There are almost as many different ways to invest in wind energy projects as there are wind energy projects. Because wind energy projects involve a great deal of up-front costs (see the following section), project developers must often use a number of ways to gather the funds necessary. Often, entities such as investment banks, large corporations and investment funds will choose to buy an ownership share in wind energy projects, both to earn a return on their investment and also to take advantage of the tax credits the wind energy project creates. Loans also may be used to provide project funding through debt. Since these loans will often have fixed payments, the developers will be concerned with making the project cashflow in the early years so these loans may be repaid on time. In other cases, individual landowners may pool their land and capital to build a project on their own properties. These groups may sometimes partner with a large investor in an arrangement known as a “Minnesota Flip.” The large investor will take the primary ownership of the project (in some cases, 99 percent ownership) in the first 10 years to take advantage of the tax benefits of owning the project. At the end of the 10 years, when the majority of the loans on the project are paid off and the tax credits are expired, they will then turn ownership over to the landowners to take advantage of the cash flows at the end of the project.

Understanding Wind Energy Agreements

Objectives

After reading this section, you will understand:

1. How are wind energy agreements are structured?
2. What are easements commonly required in wind energy agreements?
3. How may wind energy agreements affect the use of your land?
4. Why do wind energy agreements have long durations?
5. What are your obligations as a landowner under the wind energy agreement?
6. How are payments set by the wind energy agreement?
7. What happens when the wind energy agreement is over?
8. How can landowners can manage the expense of legal assistance?
9. How to find an attorney to help you analyze your agreement.

The wind energy agreement

For the purposes of this chapter, wind energy agreement will refer to the document or documents that work together to govern the relationship between the landowner and the party constructing and operating the wind power project.

Before beginning this discussion, it is important to note a wind energy agreement is an important and complex legal agreement with a long duration that can have significant economic impacts. You should strongly consider contacting an attorney with experience in negotiating wind energy agreements to assist you before executing such a document.

How are wind energy agreements structured?

When you sit down to review a wind energy agreement you might think it resembles the oil and gas leases you have seen before. To some extent, this makes sense. A company wants to enter a landowner's property, construct facilities, extract an energy resource, and send that resource to market. However, when comparing a typical Producers 88 form oil and gas lease side-by-side with a wind lease, the differences between them can be quite apparent.

While an oil and gas lease may often be a two-page, fill-in-the-blank document, the wind energy agreement frequently exceeds 30 or 40 pages. The difference? First, the oil and gas lease comes with a century of case law, statutes, regulations, and industry custom built into it, while the wind energy agreement is often an entirely new creation of the wind energy developer. Second, while the primary duty for a mineral interest owner is often to stay out of the way, the relationship between wind power developer and landowner is much more complex and must be (or at least, should be) spelled out in detail within the agreement. Finally, the typical financing arrangements for an oil and gas well differ starkly from those for a wind power project, and a great deal of the language and terms contained in the wind energy agreement may be dictated by lenders or investors rather than the developer itself, complicating the negotiation process.

As you look at your wind energy agreement, understand you may be looking at something that may function like an option, easement, and lease simultaneously. As each of these tools can have very different impacts on your property interests, you must make careful note of the potential interactions among them all.

Many wind energy agreements commence with an option contract between the developer and the landowner in which the landowner grants an exclusive right to the developer to investigate the suitability of the project for development, and if the developer should so choose, to enter into a full development contract and commence project construction and operation. During this option period, the developer will likely deploy met towers (discussed in the wind energy industry chapter) to verify the wind resource, conduct environmental and wildlife impact studies, and analyze construction suitability. Option periods often vary widely, in some cases as short as one or two years, and extending to 10 years in other cases. Some states have limited option periods by statute[60] but as of this writing, no such limitations are found in Oklahoma law.

Another feature often included in wind energy agreements is a confidentiality agreement covering the site data obtained during the option period and, in many cases, most of the terms of the overall agreement. Many landowners are unfamiliar with confidentiality agreements. Understand that by signing an agreement with a confidentiality clause (or a separate confidentiality agreement), you will be bound by its terms and may not be able to discuss your wind energy agreement with others whose advice you may need. Confidentiality agreements also can restrict landowners' ability to negotiate together.

Some developers take an approach of negotiating the agreement in its entirety before execution of the option, while other developers provide only the option agreement with a term sheet for the subsequent, full agreement with the details to be negotiated if and when the option is triggered. The trend appears to be toward negotiating the agreement in its entirety before the option period starts. Understand if you choose to leave terms open after the agreement begins, factors can change, perhaps to your advantage, but perhaps to the advantage of the developer.

If the developer's investigations indicate the project will indeed work, the developer will then trigger the option and enact the full agreement. In many wind energy agreements, the assurances needed by the developer to enable project construction and operation may take the form of a collection of easements and/or a general lease of the affected property.[61] A brief summary of some of the typical terms (be they presented as easements, covenants, or contractual lease terms) follows:

Table 1 – Common Landowner Terms.

Term	*Description*
Access	Developer has right to access the property and construct roads for evaluation of site and construction, operation, and maintenance of equipment.
Construction	Developer may use portion of surface for access to construction equipment and laydown areas.
Transmission	Allows for construction of underground and aboveground transmission lines, construction and operation of substations.
Non-obstruction	Landowner will not construct any improvements that could interfere with airflow patterns on property, nor permit obstructions to occur.
Overhang	Landowner acknowledges turbine rotor discs may overhang property lines or improvements on the property.
Noise	Landowner acknowledges certain noise levels may be caused by the project (may sometimes provide for a decibel limit and a specified radius from turbines).

60 *See, e.g.* South Dakota Code §43-13-19 (limiting option periods to five years).

61 *See generally* Windustry, *Wind Energy Easement and Lease Agreements,* available at http://www.windustry.org/sites/windustry.org/files/LandEMain.pdf.

Most of the wind energy agreement will likely revolve around securing these terms, establishing the compensation package for the landowner, and defining the other parameters of the parties' legal relationship. While hundreds of pages could be written about the issues to be considered in evaluating a wind energy agreement, this chapter will focus on what are arguably the six most important questions for the you to analyze as you evaluate the proposed agreement. These questions are:

1. How will current uses of the property be affected by the project?
2. How long will the agreement last?
3. What are the landowner's obligations under the agreement?
4. How will the landowner be compensated?
5. What happens when the project ends?
6. How may the wind energy agreement affect the use of my land?

Assuming the developer builds and operates the project, you will be sharing the surface of your property with the project. While this should result in a new revenue stream for you, in all likelihood you will also want to continue your existing uses of the property to the maximum extent possible, thereby making the wind power project revenues supplemental rather than replacement funds.

Generally, a wind power project will only physically occupy three acres of land per megawatt of turbine capacity.[62] While this often leaves much of the property available for crop, livestock, or recreational uses, inconveniences can be caused by changed fencing configurations, the fragmentation of crop areas, blockages to irrigation systems, and changes to drainage patterns. These concerns should be raised during the initial contract negotiations to determine if reasonable accommodations can be reached either to minimize these disruptions or for additional compensation to mitigate them. This may be in the form of liquidated damages language. This is language that provides agreed-to compensation for each event (for example, a specified dollar amount for each fence breach, each linear foot of terrace repair needed, etc.). Some states other than Oklahoma also have proposed guidelines for maintaining the agricultural viability of property under wind power development, addressing issues such as drainage pattern preservation, minimizing soil disturbance, preserving vegetative cover, and the like.[63]

Another frequent use of land that may be impacted by wind power development is recreational leasing, frequently in the form of hunting agreements. In many wind energy agreements, hunting may be completely prohibited on the affected property during the construction phase to minimize risk to construction crews. However, wind energy agreements also may contain broad indemnification language that makes the landowner responsible for injuries of project personnel or damage to project equipment caused by hunting lessees or other assignees of the landowner (for a discussion of these indemnity issues, see the section "What are the landowner's obligations under the agreement"). Landowners should discuss compensation for loss of lease revenues to the extent such losses are caused by the project.

Aesthetic uses of the property (sometimes called beauty or scenic uses), as well as of surrounding property, may also be a concern. These may include noises from the turbines, as well as visual impacts. Noise impacts may be easier to handle in the terms of the agreement, and often come in the form of a noise easement whereby the landowner stipulates that the turbines may cause certain noise levels (often defined in decibels or dB) within a certain range of the turbines. Visual impacts are far more difficult to address. In the case of Rankin v. FPL Energy, LLC, Texas' Eleventh Court of Appeals refused to stop the operation of a wind power project on the basis that aesthetics were not a sufficient basis to award damages based on

62 See American Wind Energy Association, Wind Energy and the Environment, available at http://www.awea.org/faq/wwt_environment.html. The American Wind Energy Association estimates the total "land use" per megawatt of capacity is 60 acres, with three acres physically occupied by the project, and the remaining 57 acres used only as an unobstructed clear area to preserve wind flow to the turbine array.

63 *See*, e.g. New York State Department of Agriculture and Markets, *Guidelines for Agricultural Mitigation for Wind Power Projects,* available at http://www.farmlandinfo.org/documents/30658/NYS-DAM-Wind-Power-Guidelines.pdf.

64 *See Rankin v. FPL Energy,* LLC, -- S.W.3d --, 2008 WL 3864829 (Tex. App. 2008).

negligence.[64] Several other cases also have cited the subjectivity of aesthetics claims in suits involving wind power projects – in other words, beauty is in the eye of the beholder.[65] Nevertheless, both developers and landowners should consider possible opposition to projects by neighbors.

The landowner's participation in governmental programs can also have an impact on the use of the property for wind energy development. Several USDA programs such as the Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), the Grassland Reserve Program (GRP) and other common programs for Oklahoma landowners require participants to have multi-year contracts and plans for the use and maintenance of the land under contract. Constructing wind power equipment on such lands in violation of those contracts or plans could cause landowners to forfeit future payments, return of past payments, or even pay penalties.[66] If the project lands are under any USDA program contracts, the appropriate agencies should be contacted to discuss integration of the project under the contract plans prior to execution of the wind energy agreement.[67] Landowners should consider negotiating agreement language providing any loss of revenues from such programs caused by the wind power project should be compensated by the developer.

Finally, landowners should explicitly reserve the right to use the property for agricultural, recreational, and other uses. From the landowner's perspective, such a reservation should be as broad as possible while still allowing the developer the rights necessary to construct, operate, and maintain the project. Similarly, landowners also should be careful not to grant away access to other resources on the property without fair compensation as many wind energy agreements offered by developers may contain provisions granting the developer free access to water, rock, and other materials without any additional payment to the landowner.[68]

Why do wind energy agreements have long durations?

With some of the early leases circulated in Oklahoma, the sum of the primary lease terms plus the automatic renewals could be up to 150 years. For some historic perspective, a 150 year lease executed at the start of the Civil War would have just concluded last year. This fact alone frequently shocked landowners to the point of rejecting any further consideration of the lease. Long lease terms reflect the classic struggle, seen for many years in the oil and gas industry as well: a resource developer wants to secure access to the resource at a fixed price for as long as possible, while the landowner would like to continually offer access to the resource back to the market if a better price may be secured. While some leases with these 150 year terms may still be offered, they are becoming rare. The general trend seems to be toward shorter periods, often ranging between 20 and 40 years.[69] From the developer's perspective, a lease period must be of sufficient length to recapture the project's costs and return an acceptable profit to project investors. Many wind turbines today have an expected lifespan of approximately 20 years, and thus, developers may be reluctant to agree to a term less than that period.

The effect of these circumstances may lead to long-term leases with renewals that are solely in the discretion of the project developer. However, while it may be difficult to get initial

65 For a compilation of such cases, *see generally* Stephen Baron, New Meets Old: Wind Turbines and the Common Law of Nuisance, University of Texas Wind Energy Institute (February 19-20, 2008, Austin, Texas), available at http://www.utcle.org/eLibrary/preview.php?asset_file_id=15069.

66 *See, e.g.,* 7 C.F.R. § 1410.32(h), providing that termination of a CRP contract will trigger repayment of all amounts received by the landowner under the contract, plus interest.

67 For an excellent discussion of these programs, *see generally* Farmers Legal Action Group, Inc., *Farmers' Guide to Wind Energy: Legal Issues in Farming the Wind* and its discussion of "Impact[s] on Farm Program Eligibility" at pp. 4-8 et seq., available at http://www.flaginc.org/topics/pubs/index.php#FGWE.

68 Agreements that seek water rights from the landowner are of particular concern. Wind energy facilities do not require water for their operation, and thus landowners confronted with such a provision must undertake special care to determine the proposed use of, and compensation for, their water by a project developer.

69 *See* Windustry, *supra* note 2.

terms in smaller increments, there may be opportunity for negotiating the terms of lease renewals. Thus, the first step for the landowner is to carefully analyze the duration of the agreement. Some agreements are quite forthright in defining a duration, but others may not be as clear.

If the project developer is unwilling to negotiate the overall length of the agreement, it may be possible to negotiate a reopener term that allows for negotiation of some commercial terms at renewal periods. It is important such reopeners be tied to the compensation terms of the agreement to minimize downside risk with a price floor for the landowner if electrical markets should trend downward at the time of lease renewal. The landowner also may wish to reopen the entire agreement if the project is to be repowered (that is, existing project turbines are removed and replaced with new larger or more efficient turbines).[70]

Finally, many landowners may overlook the fact that entering into a wind energy agreement may impact their estate plans. The length of these agreements makes it quite possible successors to the land in question will take the property subject to the agreement. Thus, landowners may need to involve those successors in discussions about the agreement as part of their succession planning efforts.

What are your obligations as a landowner under the wind energy agreement?

As mentioned above, wind energy agreements differ from oil and gas agreements in there may be many more on-going duties faced by the landowner under a wind energy agreement. First among these obligations is likely the non-obstruction term of the agreement that requiring the landowner to avoid (and in some agreements, actively defend against) the creation of any condition that could interfere with the flow of wind over the surface of the property. While this may not seem like a significant constraint, studies have shown even relatively low structures such as houses and barns can cause turbulence downwind of the structure for distances of 15 to 20 times the structure's height (see the discussion of turbine siting issues in the wind energy industry chapter).[71] Depending on the size of the parcel in question, this principle, or an express set-back provision in the agreement, may effectively block the construction of any new improvements on the land unless an agreement is in place allowing for discussion of potential improvements with project engineers. If you have any plans for improvements, such plans should be raised to the attention of the developer as the agreement is considered. You also may need to examine the agreement to see if it requires you to affirmatively eliminate other obstructions, such as trees, and if it prohibits the leasing of the land for any other uses such as cellular towers.

Another significant issue may be the indemnification provisions of the wind energy agreement. The concept of indemnification itself may be new to many landowners. Adding to this is the fact the indemnification provisions of many wind energy agreements are the provisions developers are least willing to negotiate.[72] Indemnification is an agreement to reimburse another party for damages they sustained as the result of another party's actions. Indeed, some agreements will effectively hold the landowner liable for any damages or injuries that are not the result of negligence or willful misconduct by the developer. Landowners also may be required to take on greatly increased insurance limits to satisfy these indemnification obligations.

Landowners should seek a balanced and fair indemnity relationship. For example, if the project site is under a hunting lease, the landowner and developer may consider a standard indemnification agreement to be executed by

70 *See* Windustry, *Wind Energy Easements and Leases: Best Practices and Policy Recommendations,* available at http://www.windustry.org/sites/windustry.org/files/LandEBestPractices.pdf.

71 *See* J.F. Manwell, J.G. McGowan, and A.L. Rogers, Wind Energy Explained: Theory, Design and Application at 47 (2002).

72 *See* Neil Hamilton, "Roping the Wind: Legal Issues in Wind Energy Development in Iowa," American Agricultural Law Association Symposium, (October 25, 2008, Minneapolis, Minnesota).

the hunting lessee that provides the lessee will be responsible for any damages or injuries caused by its presence on the property. Landowners also should consider negotiating indemnity language that explicitly exonerates the landowner from liability for the actions of trespassers and any other parties not under the direct control of the landowner. Finally, increases in insurance requirements for the landowner should be a consideration in compensation negotiations.[73] Landowners should insist on the insurance coverages required by the Oklahoma Wind Energy Development Act.[74]

Another potential hazard for landowners may come from the legal interests created in the property by the wind energy agreement. If the land is subject to an agreement with a secured creditor, such as a mortgage, it is quite likely that creation of an interest in the property without the consent of the secured party could constitute an event of default in that separate agreement. In the case of some mortgages, this default may make the entire amount owed due and payable immediately. As a result, creditors' consent may be needed prior to execution of a wind energy agreement.[75] Conversely, many wind energy agreements often require the landowner to secure "subordination" agreements from creditors (meaning that the other creditors must agree that they will not foreclose on the property if the effect of that foreclosure would be to constructively evict the developer) and may restrict or prohibit the creation of any new encumbrances on the property. Landowners' equity in real property may be a significant source of capital, especially in agriculture, and such provisions could pose challenges for accessing that equity. At a minimum, landowners should involve their lenders in the wind energy agreement discussion and work out an arrangement allows the landowner to meet their lending and liquidity needs, prior to executing the wind energy agreement.[76]

Finally, a natural concern for developer and landowner alike is the potential conflict between development of the surface for wind energy projects and the development of the property's oil and gas resources. It is one of the more well-established points of Oklahoma law that the mineral estate is dominant over the surface estate.[77] However, it would also appear a shift toward a greater accommodation of surface interests has been underway. Early cases held that an oil and gas lease necessarily implied that a lessor or claimants under him would not improve land at all, thereby interfering with lessee's rights to the surface.[78] However, those rights have been increasingly limited by the concept of reasonableness. For many years, Oklahoma's common law provided those with interests in the surface were entitled to damages for use of the surface that exceeded the reasonable and necessary use of the surface by the mineral interest owner.[79] This reasonable and necessary concept has been applied by Oklahoma courts seeking to set the boundaries of previously undefined easements for use of the surface of land.[80]

Thus, one must wonder what would happen in the event a wind turbine and an oil well needed to occupy exactly the same location. As discussed in the wind energy industry chapter, that optimal wind turbine placement is critical to project profitability. It is also conceivable that geologic conditions could dictate a mineral interest owner place a well at the same location in order to access the oil and gas resource. Holding to a strict dominance concept would mean the wind turbine loses in this scenario, but one

73 For a thorough discussion of liability issues for landowners, see generally Farmers Legal Action Group, Inc. *supra* note 6, Ch. 5, available at http://www.flaginc.org/topics/pubs/index.php#FGWE

74 17 Okla. Stat. § 160.19 requires developers to have commercial general liability insurance that includes the landowner as a named insured on the policy.

75 *See* Farmers Legal Action Group, *"Negotiating Wind Energy Property Agreements,"* available at http://www.flaginc.org/topics/pubs/arts/WindPropertyAgrmnts2007.pdf.

76 See id.

77 See, e.g. Enron Oil & Gas Co. v. Worth, 947 P.2d 610 (Okla. Civ. App. 1997).

78 See Conway v. Skelly Oil Co., 54 F.2d 11 (lOth Cir. 1932).

79 See Houck v. Hold Oil Corp., 867 P.2d 451,458 (Okla. 1993).

80 See Head v. McCracken, 102 P.3d 670, 677 (Okla. 2004), stating:

> [I]f said attributes [including the location and extent of the easement] are not so fixed by the terms of the granting or reservation instrument, the owner of the dominant estate ... is ordinarily entitled to a right of way of such width, length, and location as is sufficient to give necessary or reasonable ingress and egress over the other person's land.

must consider whether asking a surface estate owner (or in this case, his or her lessee) to move or at least deactivate a multi-million dollar turbine would constitute an unreasonable interference with surface use.

Some wind energy agreements purport to override any previously granted rights to develop the mineral estate underlying the surface property, but these provisions should be struck as a nullity under Oklahoma law. On the other hand, some newer wind energy agreements ask the developer be forwarded notice of any indication that the mineral interest owner intends to undertake development of mineral estate so that the parties can arrive at a mutually agreed upon plan to develop all of the parcel's resources. It seems in all but the most extreme cases, this strategy can allow for the development of the property to the satisfaction of all parties.

Additionally, the Exploration Rights Act of 2011 (52 Okla. Stat. §§ 801-805) requires a wind energy developer to provide notice to any oil and gas operators on the property of their intent to construct a wind energy facility so the two can work together to develop a plan to cooperatively develop the property.

How are payments set by the wind energy agreement?

At the core of every wind energy agreement is the issue of compensation, and there are almost as many different ways to calculate landowner payments as there are landowners. However, there are a number of measures that are commonly used across agreements.

When evaluating the payment terms of a lease, one should consider whether the payments vary by the phase of the project. Generally, wind power projects are divided into an option or preconstruction phase (during which the project's viability is evaluated), a construction phase (occurring after the option has been exercised but before commercial production of energy has commenced), an operation phase (during which the project is generating and selling power), and possibly a decommissioning phase (when the project has wound up and is dismantled). The landowner should be aware of how the project's phases will affect payments, and what milestones trigger each phase.

One common factor used as a compensation basis is the acreage involved. While this often is the denominator for rural land leases, it bears mention that the acreage held by a landowner may hold little proportion to the other important metrics of the wind power project, such as the number of turbines in place on the property or the turbines' generating capacity. Terrain and project geometry may mean a smaller landowner may have more turbines than his or her larger counterparts.

Another frequent factor in calculating landowner payments is the number of turbines in place on the property. In the past, landowners often received a flat amount per turbine, but the recent trend seems to be toward a per-turbine payment that is based on the nameplate capacity of the turbine.[81] Shifts in the dynamics of the turbine market and in the turbine technology itself have sometimes led to projects that may have multiple turbine designs, capacities, and even manufacturers represented, and this can lead to differing generating capacities. A capacity based turbine payment enables the landowner to capture the upside potential of new equipment installations.

Lastly, many agreements now provide for a royalty[82] payment to the landowner based on the production of the turbines on his or her property. This element of the landowner payment often is the most complex to understand, calculate, and verify. While the concept of a payment based on the electrical production of the project seems fairly simple, there are a number of variables that may be in play. First, the landowner must understand the basis of the payment, which may be the megawatt- or kilowatt-hours of power produced, gross proceeds from sales of electricity, net revenues from the power sold, etc. It is critical that the definition of

81 *See generally* Windustry, *"Wind Energy Leases and Compensation Packages,"* available at http://www.windustry.org/sites/windustry.org/files/LandECompPackages.pdf.

82 Real property and oil & gas scholars may contest the use of the term "royalty" to describe these payments. For the purposes of this discussion, the term will be used to describe a payment that is correlated to the production of electrical power from the project (rather than correlated to acres or turbines).

these terms within the agreement be analyzed thoroughly. If a royalty is based on gross proceeds, do those proceeds include revenues from the sale of transferable tax credits or renewable energy credits (RECs)? If the payment is based on net revenues, what costs are deductible by the developer – and if the project sells its power on the spot market rather than under a long-term power purchase agreement (PPA), will the landowner be at the mercy of market fluctuations? Market-based measures may give landowners the opportunity to participate in favorable price swings, but should be tempered with minimum-payment provisions to secure against downside risk.[83]

Given a wind power project incurs the vast majority of its costs in its first few years of development and operation, many leases are now including a royalty escalator clause that increases the royalty percentage at specified intervals. The escalator clause can prove to be a mutually beneficial provision for both developer and landowner, allowing for more rapid cost-recovery by the developer while allowing the landowner to increase his or her participation in project profits during later years. Such escalators need to include either an explicit function for increases (specifying the intervals at which royalties will increase and in what proportion) or be indexed to an objectively-determinable, publicly available number (i.e., the U.S. Bureau of Labor Statistics Consumer Price Index, U.S. Energy Information Agency wholesale electrical price, etc.).

While royalty payments often represent the best returns for landowners, they are accompanied by the need for landowners to audit payments. As many practitioners in Oklahoma and other oil and gas producing states are well aware, numerous class action suits have been waged by royalty owners alleging mismeasurement of resources, miscalculation of royalties due, market prices skewed by affiliate transactions, and the like.

In evaluating the wind energy agreement, the landowner also must consider the situation in which he or she may execute the agreement and the project is built, but the project configuration does not allow for placement of a turbine on the landowner's property. In such a situation, some form of minimum payment to the landowner who burdened by the agreement but has not received turbine should be considered. One means of achieving this is a pooled, community, or project payment. These payments are made to landowners, based not on the performance of turbines located on their property, but rather the production of the project as a whole. These payments may serve a number of functions including compensating landowners whose property is part of the project but did not receive a turbine, as well as leveling the performance among turbines (where geographic conditions may make some turbines markedly more or less efficient than neighboring turbines).

Lastly, negotiating a most favored nation clause may be possible in some projects. As the name implies, such a clause enables the landowner to capture the most favorable easement or lease terms granted to any other landowner within the same project. This can help the landowner overcome potential oversights in the negotiating process or a lack of information regarding comparable terms. The problem with such a clause, of course, lies in its verifiability, which is complicated by the confidentially agreements typically tied to the project. It also should be noted these clauses can be used against landowners: "I can't give you what you are asking for, because if I did, I would have to give it to everyone else in the project."

An alternative for landowners is collective negotiation of a lease with their neighbors. This can increase the landowners' bargaining power and allows them to spread legal costs amongst themselves. Some developers even favor these arrangements, as they allow the developer to secure large areas of land through the negotiation of one agreement, rather than piecing together a project through individual negotiations and risking a checkerboard pattern in the land under lease.

83 *See generally* Windustry, "Wind Energy Leases and Compensation Packages," available at http://www.windustry.org/sites/windustry.org/files/LandECompPackages.pdf.

What happens when the wind energy agreement is over?

When asked by the author about project termination clauses, one developer stated "Hey, if we develop your project, we've likely sunk hundreds of millions of dollars into it, so we're not going to terminate your agreement on a whim." While this is a valid argument, landowners must understand the conditions that provide either party the ability to terminate the agreement. Often, agreements will provide a host of potential causes that can enable the developer to terminate the agreement. In such case, landowners should require, at a minimum, the immediate payment of all sums then due to the landowner. Some practitioners also have suggested requiring a termination fee that is a function of a historic course-of-payments for the landowner (i.e., a termination fee equal to the past three years of payments to the landowner).[84]

In virtually every case, the ability of the landowner to terminate the agreement will be extremely limited, and will likely be based on the non-payment of amounts due the landowner within a certain timeframe. Further, the landowner will likely be required to provide written notice of a potential termination event to the developer and provide a specified cure period. Thus, landowners should be advised to keep sound records of payments and project milestones, and to provide prompt notice of any potential defaults to preserve their rights if termination is warranted.[85]

All parties to a wind power agreement must contemplate the fact the project may eventually end, whether by completion of the operational life of all the equipment, introduction of some new energy technology, or the dissolution of the developer. A frequent fear of landowners is the developer will default or dissolve, and the landowner will be left with huge inoperable machines on his or her property. Those fears are not born from idle imagination, but stem directly from the host of abandoned oil and gas wells that once littered the Oklahoma landscape after the first half of the 20th century. To that end, many landowners have requested that wind energy agreements contain some form of decommissioning language that, at the end of the project, requires the developer to remove all equipment, restore the land to its original grade, vegetation, and soil condition, and to remove sub-surface materials to a specified depth. Further, landowners also are seeking a performance bond from the developer, the funds from which are to be used to ensure performance of the decommissioning obligations.

Decommissioning language is not found in all agreements, and frequently must be requested by the landowner. Further, the posting of a bond or other security in an amount sufficient to cover the complete costs of a decommissioning project could become cost-prohibitive for some developers. A compromise offered by some companies is a salvage value"decommissioning clause whereby the salvage value of the equipment in a project is evaluated at a specified period (for example, every five years) relative to the estimated cost of decommissioning activities. If the salvage value of the equipment falls below the estimated decommissioning costs, bonds are posted in an amount sufficient to cover the difference.

Minimum requirements for decommissioning, including requirements to remove equipment and restore soils and vegetation, are included in the Oklahoma Wind Energy Development Act at 17 Okla. Stat. § 160.14. Further, developers are also required by the Wind Energy Development Act to file a bond to ensure decommissioning is accomplished.[86] The Act specifically provides landowners and developers may negotiate decommissioning terms that are more stringent than the act.

How can landowners manage the expense of legal assistance?

At the risk of stating the obvious, reviewing a highly technical 40 page lease presenting a host of novel issues will take more of a lawyer's time than reviewing a two-page oil and gas lease with familiar provisions. Landowners

84 University of Texas Wind Energy Institute CLE, The Ultimate Guide to Wind Leases, June 2, 2006 (available from Texas Bar Association).

85 *See* Farmers Legal Action Group, *supra* note 6.

86 17 Okla. Stat. § 160.15

who realize this may be reluctant to engage an attorney for fear of the cost; attorneys may be hesitant to take clients due to the time-intensive nature of the enterprise. Collective action may serve both groups well. Most Oklahoma wind power projects will involve tens of thousands of acres, which in turn will mean numerous landowners will be involved. Such landowners may enhance their bargaining power by forming a negotiation group that enables them to share in the expense of legal services while providing the developer the ability to negotiate one agreement binding the entire group, rather than numerous individual agreements. Also, landowners should ask developers if they will provide for reimbursement of legal fees incurred in reviewing the agreement; many developers will provide such fees up to a capped amount.

How to find an attorney to help analyze your agreement

Finding the right attorney to help evaluate your wind energy agreement is crucial. As you have probably learned from reading these materials, the wind energy industry, and wind energy agreements, are unlike almost any other industry Oklahoma landowners will encounter. Specialized legal experience in the wind energy industry is crucial to providing the best service possible to landowners. As a result, when you are looking for an attorney to help analyze your wind energy agreement, one of the first questions to ask is "what experience do you have in negotiating wind energy agreements?" Demand specific details; don't settle for generalities like "I do this sort of thing all the time," or "I've negotiated hundreds of oil and gas leases – they're just the same" (they are not, as you have seen here). The good news for landowners is the growth of Oklahoma's wind energy industry has brought about an increasing number of attorneys who do have experience in this area. When looking for such attorneys, a good place to start is in those areas that already have a significant number of wind energy projects.

Once you have found some candidates, ask them for reference clients you can contact to discuss the clients' experiences with the attorney, and the quality of their representation. You may also want to ask those references for secondary (or indirect) references you may contact.

Lastly, when hiring a new attorney, be sure to check with the Oklahoma Bar Association to make sure the attorney is currently licensed, in good standing, and has a clean disciplinary record.

Wind energy agreements are complex, important documents – be sure you get the help you need in negotiating and executing them!

Impacts of Wind Leasing Projects

Objectives

After reading this section, you will understand:

1. What environmental impacts can a wind energy project have on its surroundings?
2. How does the Endangered Species Act impact wind energy projects?
3. How does the Clean Water Act impact wind energy projects?
4. What is the doctrine of nuisance?
5. What are the nuisance impacts of wind turbine noise and shadow flicker?
6. What are the aesthetic impacts of wind energy projects?
7. Are there dangers to life and property posed by wind energy projects?
8. What is the doctrine of trespass?
9. How are injunctions used to prevent construction of wind energy facilities?
10. What are the economic impacts of a wind development project?

Introduction

Wind projects are multimillion dollar energy development ventures that will have impacts on the environment, local landowners, the community surrounding the wind projects, and the world at large. As a result, it is important that communities understand some of the potential effects and impacts in order to make informed decisions with respect to these projects.

Many of these impacts are largely dependent on the facts and circumstances of the location, the developer, the landowners and the community. This variation makes it difficult to predict a project's impact just by comparing it with other projects. For example, there may be two similar wind projects under construction; one has to deal with an endangered species in the area and the other does not. Other variations could include tax incentives, leasing contracts, the neighboring landowners, the availability of transmission lines, and a host of other factors. In this chapter, we will examine some of the issues that are unique to wind projects; however, we are not able to cover all of them or go into great detail on any one topic. Additional information on these impacts are available at the Handbook website, http://agecon.okstate.edu/wind.

What environmental impacts can a wind energy project have on its surroundings?

Some legal claims against wind farms address the actual environmental impact created by the facilities. Like any large-scale construction project, wind farms require significant areas of land even if the actual footprint of roads, transmission lines, and turbines are relatively small once construction of the project is complete. For example, the habitats of many terrestrial species may have to be excavated or cleared in certain areas to make way for site development.

However, one must also take into account the vast environmental benefits that make renewable energy popular. Taking both sides of the issue into account makes determining the overall environmental impact of a wind project much more difficult than with typical construction projects.

Measuring the impact to an ecosystem for a major construction project, whether it is a wind farm or a new football stadium, is one of the first necessary steps. The National Environmental Policy Act of 1969 requires that an environmental impact statement be prepared for any project where federal funding or permitting is required. As a result of this requirement, many large construction projects over the past 40 years have required analysis of the adverse impact that the project may have on the surrounding ecosystem. These environmental impact statements focus on the adverse impact of the project on the location and how best to minimize it, if possible, while taking into account the potential environmental benefits of the project to the community, the state and the country.

For example, how do you weigh the potential damage to a local watershed because of the runoff from access roads (which is measurable and an issue under the Clean Water Act) to the reduction of the use of coal in a power plant that may be out of state and has no direct environmental significance to the wind project itself? Questions like this are difficult to address, but they are important in determining the overall environmental impact of a particular project.

These issues become even more difficult when we consider the fact that every wind project throughout the world is unique to itself. No two projects are exactly alike, especially when taking into account differences such as the amount of rainfall, the type of soil, the local wildlife, the location of people, the topography of the land, and many other factors too numerous to count. As a result of these many differences, the environmental impact of each project will be unique. In one part of the country there might be significant problems with water quality before the wind project has even begun. In that case, the developers will have to be extremely careful in making sure that they are compliant with the Clean Water Act issues involved in runoff from roads. In another part of the country an important issue may be a threatened or endangered species that is found in an area where a project is considered for development.

How does the Endangered Species Act impact wind energy projects?

In some locations, protecting endangered species must be balanced against providing innovative and reliable renewable energy. The Endangered Species Act is not a new law and many farmers and forestland owners are aware of some of the issues that may arise under it. In 1973, Congress passed the Endangered Species Act in response to the growing concern about the extinction of animal and plant species.[87] In the legislation Congress noted the Act was meant:

> to provide means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of treaties and conventions.[88]

Simply put, this statute is focused on protecting endangered or threatened species. However, it protects and preserves not only the animal itself, but also the ecosystem where it is found. To accomplish this purpose, the federal government passed this statute forbidding the taking of any listed species. What makes this statute so broad (and important to the wind industry) is the expansive definition of the word take[89] which means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect or to attempt to engage in any such conduct.[90] Additionally, the Endangered Species Act includes a further requirement to find the critical habitat for the animal and attempt to minimize

87 *Gibbs v. Babbit*, 214 F.3d 483, 487 (4th Cir. 2000).
88 16 U.S.C. 1531(b)
89 16 U.S.C. § 1532(19).
90 16 U.S.C. § 1532(19).

the impact on its habitat.

For example, consider an Oklahoma landowner who wants to expand his farmable acreage by bulldozing some trees. During the land clearing process, he finds a red-cockaded woodpecker nest in the patch of timber. The woodpecker is listed as endangered under the Endangered Species Act. If he continues to bulldoze the land without any other action, is he taking the animal under the Endangered Species Act? Most courts would answer yes. The definition of take is broad enough to encompass not only danger to the animal itself, but also destruction of its nest and the habitat immediately surrounding it. The Endangered Species Act is not going to make him take any affirmative action to help the animal (i.e. he will not have to build bird houses for the woodpecker), but his ability to destroy the bird's critical habitat will probably be severely limited, if not prohibited.

In terms of the Endangered Species Act and wind farm development, the primary case law comes from a West Virginia court in a suit titled Animal Welfare Institute v. Beech Ridge Energy LLC.[91] The particular species at issue was the migratory Indiana bat population, an endangered species.

Research has shown a correlation between large-scale wind energy projects and bat mortality. The two main causes of bat mortality are collisions and barotrauma.[92] Barotrauma is damage caused to enclosed air-containing cavities (e.g., the lungs, eardrums, etc.) as a result of a rapid change in external pressure, usually from high to low caused by the turbines.[93] The vast majority of incidents of collision and barotrauma occur during the fall when bat populations (and many bird species) are migrating.[94] Therefore, areas through which migratory bat and bird populations are known to travel are the most at risk for high bat and bird mortality rates. While environmental impact statements prepared by wind energy projects typically address animal migration patterns, in some cases, a seasonal change might easily be overlooked if the impact statement is prepared at another time of the year.

After conducting its balancing test, the court granted an injunction against the Beech Ridge Wind Project under the Endangered Species Act. The opinion was based in part on the fact that West Virginia is home to many migrating avian and bat populations, and the damage to those populations (estimated by the court to be approximately 48 bats per turbine).[95] was too significant. In fact, the court concluded, with virtual certainty, that "construction and operation of the Beech Ridge Project will take endangered Indiana bats in violation of Section 9 of the ESA."[96] However, it is important to note that while this was sufficient for the court to grant an injunction against the specific project at issue, other judges in other states addressing other projects might reach different conclusions.

How does the Clean Water Act impact wind energy projects?

Another important environmental law affecting wind energy development is the Clean Water Act, or CWA.[97] It was first passed as the Federal Water Pollution Control Act in 1948. In 1972, the Federal Water Pollution Control Act was significantly amended, and the 1972 law (along with its subsequent amendments) are commonly known as the CWA. The CWA affects wind energy development primarily in the development stage, when roads are built for transportation of the towers and when soils are exposed in the process of constructing the turbine sites and other facilities. In some cases, the runoff from those roads is subject to the restrictions of the CWA, as is the water used in mobile concrete plants.

The CWA is implemented and enforced by the Environmental Protection Agency, or EPA, which works together with state environmental agencies and the U.S. Army Corps of Engineers. The law protects water in several dif-

91 *Animal Welfare Institute v. Beech Ridge Energy LLC*, 675 F.Supp.2d 540 (2009).
92 *Id.*
93 Edward Arnett, *Patterns of Bat Fatalities at Wind Energy Facilities in North America,* 72 Journal of Wildlife Management 61-78 (2008).
94 *Animal Welfare Institute* at 540.
95 *Id.* at 548.
96 *Id.* at 540.
97 Federal Water Pollution Control Act, 33 U.S.C. §§ 1251-1387.

ferent ways, including authorizing water quality standards for surface waters, requiring National Pollution Discharge Elimination System (NPDES) permits for point source discharges of pollutants into navigable waters, assisting with funding for construction of municipal sewage treatment plants, and planning for control of nonpoint source pollution.

The CWA is responsible for regulating navigable waters. While this term is defined in the statute as "waters of the United States, it is further defined by agency regulations and judicial interpretations.[98] The first step involves the EPA assigning water quality standards to all parts of a watershed that are within the scope of the CWA. Water quality standards are scientifically measurable standards that quantify the goals of the CWA, based in large part on designated uses for the water body. Designated uses might include things such as fishing, irrigation, swimming or drinking. A single body of water can have multiple designated uses.

Water quality standards set allowable pollutant levels for individual water bodies, based on a review of its relevant uses and water quality criteria. Two types of standards are authorized by the CWA: narrative and numeric. The narrative method is a broader, more general standard indicating water quality. For example, a narrative standard might establish that there will be no nutrients at levels that cause a harmful imbalance of aquatic populations. The numeric standard is more specific, and requires the adoption of specific numeric standards. For example, a numeric standard may establish that the ambient water quality criterion for cadmium is 10 µg/L (micrograms per liter).

One approach that is used in order to meet water quality standards is the establishment of Total Maximum Daily Load, or TMDL limits. A TMDL establishes the maximum amount of a pollutant in a particular area of an impaired water body that would allow the water quality standards to be met. These TMDLs are then used as part of a permitting system to determine the amount of pollutants that may be discharged into the water body.[99]

The CWA requirement that most impacts wind energy projects is the regulation of stormwater discharges from construction projects under the NPDES. The NPDES requires that a permit be obtained before any pollutant can be discharged from a point source into a navigable water. The permits set the allowable amount of pollutants in a discharge, with a pollutant"being very broadly defined and including heat, waste, soil, rock and chemical or biological materials. However, only discharges from point sources that are included in the permitting system. A point source includes many manmade objects including pipes, ditches, tunnels and roads. Since the construction of a wind energy project will expose soils (although sometimes this exposure is temporary) to rainfall, the runoff of that rainfall may carry materials to a nearby

98 The definition of "waters of the United States" is very broad, and can be found at 40 U.S.C. § 230.3(s): 40 CFR 230.3(s) The term waters of the United States means:
(1) All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
(2) All interstate waters including interstate wetlands;
(3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
(i) Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
(ii) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
(iii) Which are used or could be used for industrial purposes by industries in interstate commerce;
(4) All impoundments of waters otherwise defined as waters of the United States under this definition;
(5) Tributaries of waters identified in paragraphs (s)(1) through (4) of this section;
(6) The territorial sea;
Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (s)(1) through (6) of this section; waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States.

99 For more information on TMDLs in the United States, see: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/
For more information on TMDLs in Oklahoma, see: http://www.deq.state.ok.us/wqdnew/tmdl/index.html

water body. For this reason, most wind energy projects will be required to have a construction stormwater permit under the NPDES.

NPDES permits are issued by the EPA, or by the state environmental agency if that state has a program that has been approved by the EPA. The permits may be issued to either individual dischargers or groups of similar dischargers. The permits set measurable limits on the amounts of pollutants allowed to be discharged. These limits may be based either on technology (technology limits) or water quality standards. Permits may also contain best management practice requirements. Best management practices are the best known and most practical methods for reducing pollution levels in a particular industry.[100]

The other permitting system that may affect wind energy development is a program called Section 404. Section 404 of the CWA regulates the deposit of dredged and fill material into navigable waters. The U.S. Army Corps of Engineers and EPA jointly administer and enforce this program. The Corps is responsible for issuing individual permits and enforcing the provisions of the law, while EPA develops the criteria used in evaluating the applications, while also reviewing and commenting on the permit applications. EPA also has the authority to veto permit decisions made by the Corps. In order to obtain a §404 permit, applicants must demonstrate that the discharge of dredged or fill material will not significantly degrade the nation's waters and there are no practicable alternatives that are less damaging to the aquatic environment. The application should also describe steps taken to minimize impacts to water bodies and wetlands as well as provide appropriate and practical mitigation (such as restoring or creating wetlands) for any remaining impacts.[101]

Provisions of the CWA, especially those dealing with permitting, may come into play for a wind energy project in the development stage, when developers are mixing concrete and building and maintaining roads for the movement of equipment and towers.

100 For more information on the NPDES permitting program in the United States, see: http://cfpub.epa.gov/npdes/home.cfm?program_id=45
For more information on the NPDES permitting program in Oklahoma, see: http://www.deq.state.ok.us/wqdnew/opdes/index.html

101 For more information on the §404 permitting program in the United States, see: http://water.epa.gov/type/oceb/habitat/cwa404.cfm
For more information on the §404 permitting program in Oklahoma, http://www.deq.state.ok.us/wqdnew/401_404/index.htm

What is the doctrine of nuisance?

The vast majority of cases involving wind farms are brought through a cause of action called nuisance. The purpose of nuisance litigation is to stop bothersome activities or conduct that unreasonably interferes with another landowner's use and enjoyment of his or her land. Nuisances are divided into two groups– public nuisances and private nuisances.

A public nuisance is one that unreasonably interferes with the public's right to property. It addresses conduct that interferes with public health, safety, peace or convenience, and is meant to address claims that affect an entire community of people. Because wind energy is subsidized by the government and is meant to benefit the public through the production of efficient and renewable energy, claims against wind energy production on public nuisance grounds are relatively unlikely.

A private nuisance, on the other hand, is an invasion of another's interest in the private use and enjoyment of land.[102] Often, nuisance issues are addressed by a lawsuit brought by the person whose use and enjoyment is being limited. However, it is necessary for the party bringing the lawsuit (the plaintiff) to establish that the creator of the nuisance has intent, or is aware, that such a nuisance has been created and is affecting other people. For example, if a factory produces pollution that is transported to a neighboring property, and the factory is aware of this occurrence, the residential owner likely has a cause of action for a private nuisance against the factory.

Another crucial factor in whether a nuisance lawsuit may be maintained is the whether the action is unreasonable. This requires the finder of fact (either a judge or jury) to consider the usefulness of the action versus the severity of the harm it causes. In terms of wind energy,

102 Restatement 2ND of Torts 821D (1977).

this would balance the usefulness of the wind turbine itself with the effect the turbine has on the neighboring landowners. It will take into account the location of the wind energy project and its setting around residential and/or commercial areas as a major factor in determining just how unreasonable the alleged nuisance is.

The remedies most often sought by neighboring property owner plaintiffs are injunctions, which prevent the operation of a wind farm in a particular place, and damages, where the plaintiffs seek payment for the damages that they have suffered.

Wind farms on a large scale are a relatively new development in many areas of the country, including Oklahoma. As a result, there is relatively little case law regarding wind turbine projects as opposed to other areas of the law such as oil and gas law. However, of the case law that does exist, much of it focuses on issues that are discovered during and after the construction of the wind farm.

Cases have been brought on the basis of noise and vibrations that are produced by the rotation of the wind turbine blades, as well as on the basis of potentially dangerous situations such as ice throw, blade shear and turbine collapse. Ice throw, as the term implies, happens when a wind turbine blade collects ice and as a result of a wind gust, the ice flies off the blade and is propelled a distance from the actual turbine. Blade shear, which is due largely to faulty maintenance, occurs when a blade falls from the rotor. And finally, other cases have been brought on aesthetic grounds, based on their correlation with the reduction of property values. Any of these reasons may be used as grounds to bring a nuisance action; however, the likelihood of success depends greatly on the individual facts surrounding each unique issue.

What are the nuisance impacts of wind turbine noise and shadow flicker?

The most frequent sources of nuisance claims against wind energy projects are the noise, vibrations and strobe effect or shadow flicker produced by the wind turbines. Observers have labeled the noise produced by the operation of wind turbines similar to a buzzing or sizzling, while some researchers have stated that it is very similar to that of other ambient noises, including, but not limited to, the simple sound of wind.[103] An Ohio court described shadow flicker as a potentially annoying phenomenon caused by the swinging of turbine blades between the ground and the sun.[104]

Again, these types of nuisances depend on a reasonableness balancing test in order to determine whether the utility of the wind farm outweighs the alleged nuisance it would create. A significant factor that is taken into account when conducting the balancing test is the fact that a wind energy production facility creates no actual environmental pollution, unlike some non-renewable energy sources such as coal and nuclear power. This is an important point for evaluation because of the standard that the conduct be a substantial and unreasonable"interference with the complaining landowner's use and enjoyment. As a result of this substantial and unreasonable standard, some courts are unwilling to recognize nuisance claims against wind farms.

Claims concerning the creation of noise, vibrations, and shadow flicker are of substantial importance and are a more likely route for a successful injunction against a wind energy production facility because of the potential health related issues caused by the spinning of the turbine blades.

For example, common law in West Virginia allows noise alone to create a nuisance depending on its time, locality and degree.[105] These elements are evaluated using a balancing test to determine if substantial and unreasonable interference has taken place. After applying the balancing test, a West Virginia court found that if an unusual and recurring noise is introduced in a residential district, and the noise prevents sleep or otherwise disturbs materially the rest and comfort of the residents, the

103 Butler, Stephen H. *Headwinds to a Clean Energy Future: Nuisance Suits Against Wind Energy Projects in the United States.* 97 Cal. L. Rev. 1337 (2009).

104 *In re Application of Buckeye Wind, LLC.,* N.E.2d Ohio 878 (2012).

105 *Ritz v. Woman's Club of Charleston,* 114 W.Va. 675, 173 S.E. 564 (1934).

106 *Id.*

noise may be inhibited by a court of equity.[106]

In a Pennsylvania case, the court considered a debate between PPM Atlantic Renewable Energy and the county Zoning Hearing Board. While the Board argued in favor of a study for the amount of noise that the turbines would create, the wind energy company argued that such a requirement upon them was not even necessary because the noise level would not "exceed 70 decibels when measured from [a] property line."[107]

In at least one case, a Washington court addressed the issue of shadow flicker. The court considered a formula of four times the height of the turbine to be a reasonable setback from neighboring property to eliminate the strobe effect when the sun is at the horizon. The defendant wind energy production company, in response, argued that the effect would disappear at a distance of 2,000 feet, and that such a setback would limit over 40 percent of their production capacity. The court utilized this information as part of its balancing test, and refused to issue an injunction against the wind farm.[108]

Nuisance claims regarding noise, vibrations and shadow flicker have been brought against wind development projects. It is important to remember, however, that the balancing test will be applied to these claims in order to determine whether the utility of the wind farm outweighs the nuisance. Typically these claims are brought after the wind farm is operational ,and at that point, the court would have to weigh the nuisance to the neighboring landowner versus the millions of dollars that went into the project. There have been successful nuisance claims against wind projects; however the number of successful law suits is much lower than the number of unsuccessful suits.

107 *PPM Atlantic Renewable v. Fayette County Zoning Hearing Bd.,* 13 Pa. D. & C. 5th 458, 492 (2010

108 *Residents Opposed to Kittitas Turbines v. State Energy Facility Site Evaluation Council,* 197 P.3d 1153 (2008).

What are the aesthetic impacts of wind energy projects?

A lawsuit based on the aesthetics of the wind facility is another potential legal theory behind a nuisance suit, though most cases brought on this ground to date have failed. A landowner's viewshed, or the scenic view from his or her property, is often correlated by landowners to property value. The perceived negative impact of the wind turbines on this viewshed provides the grounds for the suit.

There is relatively little case law addressing the aesthetics of wind farms, but historically American courts have been unwilling to prevent energy production projects because of their alleged ugliness or unsightliness. The very obvious reason behind this unwillingness is the subjectivity of aesthetics. As a West Virginia court stated, "Equity should act only where there is presented a situation which is offensive to the view of average persons of the community. And, even where there is a situation which the average person would deem offensive to the sight, such fact alone will not justify interference by a court of equity."[109]

Beliefs about the beauty of a wind farm can vary dramatically from one person to the next. While judges ordinarily apply the reasonable person standard in determining what an average, ordinary member of the community would do, that test is very difficult, if not impossible, to apply to this situation. To highlight this very point the International Energy Agency explained that "the impact of wind farms on visual amenity is probably the most controversial and difficult to quantify of all the… issues of wind energy development."[110] As a result, lawsuits based on aesthetics alone have a small likelihood of success.

Similarly, in many courts the reduction in property value alone, is not enough to suc-

109 *Burch v. Nedpower Mount Storm, LLC,* 220 W.Va 443, 455 (2007).

110 Organisation for Economic Co-operation and Development, International Energy Agency – Benign Energy? The Environmental Implications of Renewables (1998).

ceed in a lawsuit. In denying an injunction, the West Virginia court discussed above found that while the eyesore wind energy facility may have decreased neighboring property values, that alone was not enough to sustain a claim for nuisance.[111] However, courts may consider both aesthetics and a reduction in property value as additional factors in the balancing test of determining if the nuisance is unreasonable. As a result, these arguments may be more successful if combined with other claims.

Are there dangers to life and property posed by wind energy projects?

Another category of nuisance claims considers the possible dangers posed to life and property by the operation maintenance (or improper maintenance) of a wind energy production facility. As discussed earlier, a few of these concerns are the potential of ice throw, blade shear and collapse.

Because ice throw occurs primarily as a result of wintry weather conditions, they often have little to do with improper maintenance. In a Pennsylvania case involving ice throw, the court considered a study from Pennsylvania State University. The study determined that the maximum potential distance of ice throw from a wind turbine around 260 feet in height was 425 feet, or approximately two times the height of the turbine.[112] As a result of the study, the defendant, Fayette County Zoning Hearing Board, determined that the appropriate setback from the road or adjacent property for a wind turbine should be 500 feet. The Pennsylvania court was ultimately unwilling to force the relocation of the turbines to a setback of 500 feet because the adjacent private landowners had consented to the facility and received direct benefit from its operation.[113] The court further held that the risk of ice throw onto a participating property [was] not a detriment to the public.

Unlike ice throw, blade shear and collapse, while still strongly affected by extreme weather conditions, are largely the result of faulty, negligent, and improper maintenance. Blade shear occurs when a rotor blade drops, or is thrown, from the turbine. [114] Blade shear is often of very serious concern to neighboring property owners because, at the very least, it presents an actual danger. The property owners' worries are reasonable, in a sense, because many blades are mounted over 300 feet from the ground, and their tips can reach out to over 150 feet from the rotor hub. According to evidence presented in an Ohio court, however, no member of the public has ever been injured by blade shear, and "technology now includes two independent braking systems that will automatically shut down a turbine at wind speeds over the manufacturer's threshold."[115]

California, which leads the country in the number of accidents during the last three years, is third in total wind power produced, at 4,287 MW output. Conversely, Texas, which has had only seven accidents in the past three years, leads the country in wind energy production with a total output of 10,648 MW.

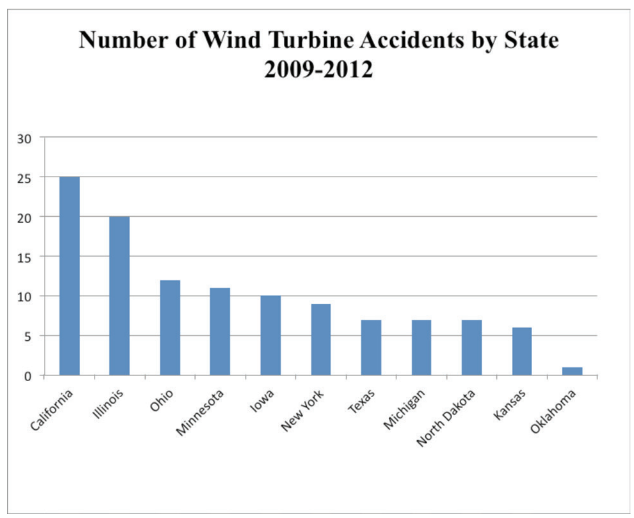

Figure 24. Number of Wind Turbine Accidents by State.
Source: www.caithnesswindfarms.co.uk [116]

111 *Burch* at 455 (2007).
112 *PPM Atlantic Renewable* at 475.
113 *PPM Atlantic Renewable* at 476-477.

114 *In re Application of Buckeye Wind, LLC.*, N.E.2d Ohio 878 (2012).
115 *Id.*
116 Caithness Wind Farm Information Forum, available at http://www.caithnesswindfarms.co.uk/fullaccidents.pdf (last visited November 28, 2012).

What is the doctrine of trespass?

The torts of nuisance and trespass have some common elements, but are two separate issues. As discussed earlier, nuisance is an unreasonable and substantial interference with the use and enjoyment of your property. Trespass, on the other hand, is a physical invasion of your property by a person or a foreign object. Trespass and nuisance are distinguished by whether the property invasion is tangible or intangible. In terms of wind farms, shadow flicker and noise are examples of intangible things that can enter your property and may be sufficient to support a nuisance claim. Trespass typically requires a physical object to enter your property. A thrown piece of ice or debris landing on your property, or a nearby turbine overhanging your property line, are examples of a trespass. Lawsuits against wind development companies may incorporate claims of both nuisance and trespass.

How are injunctions used to prevent construction of wind energy facilities?

Some landowner claims against wind farms have included requests for injunctions. Injunctions are court orders requiring a party to do, or refrain from doing, specific acts. They are only issued if each element, or factor, of the injunction test is met. In order to obtain an injunction in Oklahoma, the plaintiff has the burden of showing four elements. They must show: (1) actual success on the merits; (2) irreparable harm unless the injunction is issued; (3) that the threatened injury outweighs the harm that the injunction may cause the opposing party; and (4) that the injunction, if issued, will not adversely affect the public interest.[117]

If an Oklahoma landowner wishes to obtain an injunction prohibiting the construction of a wind turbine project, they must first establish that they won on the merits of the case. In other words, they must show that the project violated some kind of law or regulation, whether state or federal. Winning on the merits of the case could also include obtaining a declaration from the court that the project was a nuisance.

Secondly, the landowner must prove that construction of the wind farm will create imminent and irreparable harm unless the injunction is issued. The harm complained of must not be speculation–there must be a reasonable probability that it would occur.[118] Further, if the problem may be resolved through the use of money damages, the court may not issue an injunction.

Next, the landowner must prove that the alleged future harm outweighs the harm that will be suffered by the company. This is where the balancing test comes back into play. In many cases, this unnecessary hardship is based on the substantial capital investments that are necessary for construction of wind farms. In Oklahoma, a court utilized a very similar analysis in a case between a wind energy facility operator and the Osage Nation Mineral Council. In balancing the harms discussed by both sides, the court stated that:

> "An injunction prohibiting the construction of the Wind Farm will cause the following harms to Osage Wind: (a) it will lose approximately $40 million in expenses paid to date, including deposits for turbines and other equipment; (b) it will remain contractually obligated for more than $150 million of equipment purchases and construction contract penalties; and (c) it will lose the opportunity to make more than $30 million in estimated future profits."[119]

Finally, the landowner must prove that the injunction will not adversely affect the public interest. This may also be a significant hurdle. In the Osage Mineral Council case, the court cited to Congressional approval of clean energy, additional Oklahoman employment and findings of the Oklahoma legislature in determining that the injunction would, in fact, adversely affect the public interest.

117 *Fisher v. Oklahoma Health Care Authority,* 335 F.3d 1175, 1180 (10th Cir. 2003).

118 Simons v. Fahnestock, 78 P.2d 388 (Okla. 1938)

119 *Osage Nation ex. Rel. Osage Minerals Council v. Wind Capital Group, LLC,* United States District Court of Oklahoma (2011).

What are the economic impacts of a wind development project?

Impacts to the community

Measuring the economic impact of a wind farm in a community can be very difficult. There are scattered sources about the impact through tax revenue in some places, but data on payments to individual landowners can be scarce due to the proprietary nature of the information and confidentiality clauses in the lease agreements. As a general overview, decades of research and improved engineering have sought to reduce the cost of wind energy drastically. In 1979, utilizing wind power cost 40 cents per kWh, but by 2004 that cost had been reduced to between 3 and 4.5 cents.[120] Furthermore, the United States Department of Energy's *Wind Powering America* program has projected a $60 billion capital investment in rural parts of the country, with $1.2 billion of that amount going directly to the landowners.[121] Other than property tax revenue and capital investment, there is also the issue of job creation, which the American Wind Energy Association (AWEA) projects more than 80,000 new jobs in the next 20 years.[122] Depending on the project, there are an estimated six to 20 permanent jobs created per 100 MW capacity.[123]

There are many obvious cost-based advantages to utilizing wind energy versus other energy alternatives. Wind production produces 27 percent more jobs per kWh of capacity than do coal plants, and 66 percent more than natural gas.[124] In addition, wind production facilities have a much smaller demand for municipal services such as water and gas, making the projects a virtually cost-free revenue source to local jurisdictions.[125]

Additionally, nearby landowners can benefit from the high property tax on the farm itself. "Wind projects are more capital intensive than conventional power plants, resulting in property taxes that are two to three times higher per unit of energy than conventional plants."[126] The largest benefactors of this increase in local revenue from property taxes on the wind farms, especially in rural areas, are the local school districts.[127] Research has found that rural schools in Texas "have been flush with additional funds since a boom in wind development began in 1999."[128] For example, Upton County, which in 2002 had 353 MW of installed capacity, generated $3.6 million in tax revenues from wind energy projects in the county, with 95 percent of that revenue going to the school district. However, it is important to note that these results can and do vary dramatically across the country. Some states and local communities give tax breaks to entice wind projects into the community. Depending upon the amount and duration of the tax break, the amount of tax revenue realized can differ dramatically from the Texas example.

Wind farms can be beneficial to local communities and economies for a number of reasons. It is estimated that 3,400 MW produced by natural gas facilities would contribute $192 million in property taxes through 2020, while the same revenue could be garnered from just 1,700 MW of wind energy.[129] As discussed above, wind energy production requires very few local utilities like water, sewer and gas. In fact, water is only utilized in wind energy production to clean the turbines and to mix concrete onsite.[130]

President Obama has stated a goal that 80 percent of the nation's electrical power come

120 L. Flowers and M. Kelly, Wind Energy for Rural Economic Development, available at http://www.windpoweringamerica.gov/pdfs/wpa/flowers_windpower_2005.pdf.

121 *Id.*

122 *Id.*

123 *Id.*

124 K. Hale, Major Economic Impacts of Utility-Scale Wind in New York (2005), available at www.powernaturally.org/programs/wind/MajorEcoImpactsUtilityScaleWind.pdf

125 *Id.*

126 Aaron Champion, Modeling the Economic Impacts of Wind Energy Development: A Case Study of Three Oklahoma Counties, 14 (2010).

127 L. Pollock and T. Gagliano, Legisbrief: Tax and Landowner Revenue from Wind Projects (Vol. 12:5) (2004).

128 Pollock and Gagliano, *supra* note 41.

129 WashPIRG Foundation, Energy for Washington's Economy: Economic Development from Energy Efficiency and Wind Power in Washington (2003), available at http://www.washpirg.org/reports/WAenergy-June03.pdf .

130 Northwest Economic Associates, Assessing the Economic Development Impacts of Wind Power (2003), available at http://www.nationalwind.org/.publications/economic/econ_final_report.pdf.

from clean energy sources by 2035.[131] Similarly, AWEA estimates that if 20 percent of the nation's electrical capacity comes from wind power by 2020, there will 500,000 new jobs and landowners will receive around $600 million annually. Furthermore, by offsetting natural gas and other forms of energy, it is estimated that there will be $1.3 billion in consumer savings.[132]

The Landowner

Landowner revenues are one of the largest impacts on economics in terms of wind energy projects. For example, a study of the Maple Ridge Wind Farm in New York revealed that landowner revenue accounted for "21% of the total economic impacts or approximately $2.04 per MWh."[133] However, the amount and type of compensation that landowners receive varies across the country and can even vary within the same wind project.

Although the specifics of most agreements are difficult to discern because of their proprietary nature and the existence of confidentiality clauses in some cases, landowners often exercise an option in how they will receive revenue from a wind farm on their property. Landowners may negotiate their compensation as a flat payment per turbine per year, a royalty payment per megawatt produced, or some combination of the two. The payments are typically tied to property where there is at least one producing turbine. In other words, if a landowner signs a lease for development of their property, but no turbines are placed on that property, the landowner may not receive any money as a result of that lease.

Other payments that are available include signing bonuses, payments for right of ways (unless the granting of right of ways was part of the signing bonus) or even rental payments for letting the developer use the property to facilitate the construction of the project. These rental payments could encompass operations such as providing space for the concrete plant, parking for the equipment or even storage of the turbine components until they are ready to be erected.

Job Creation

Another important economic impact occurs during the construction phase of the project. The creation of jobs has been shown to benefit the local rural communities whether the labor is supplied locally or comes from another region, although the amount of that benefit may differ depending upon where the labor is coming from. For example, *Project Wild Horse* in Washington, which constructed a 229 MW capacity, employed 250 construction workers, the majority being from the immediate region and 33 percent from depressed rural counties, which accelerated local spending to $8.4 million in 12 months.[134] This example illustrates how it can be beneficial to construct a wind farm in an economically depressed region, especially if the labor force is largely drawn from the local community.

Even if the project temporarily employs outside workers, there still should be some positive economic impact to the community surrounding the wind project as those workers will be spending at least part of their wages at local businesses. This will also depend on factors that are unique to the community. For example, if the community in question is very rural and there are few businesses where the temporary workers can spend their wages, the impact could be lessened or negated.

The economic impacts associated directly with the community can be more beneficial to the area if they are manufacturing turbine parts in the community. For example, in Nebraska, a study found that if half of the necessary components needed to produce 800 MW of wind energy were manufactured in Nebraska, the state could create 250 permanent jobs, $15 million in tax revenues, and increase gross state product by $44 million over a 10-year period.[135]

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131 Office of the President of the United States 2011, State of the Union Address. January 25, 2011. Retrieved from http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address, last visited June 22, 2011.

132 Champion, *supra* note 40.

133 Hale, *supra* note 38.

134 J. Jenkins and T. Gagliano, *Wind Power and Economic Development: Real Examples from the Pacific Northwest.* Paper presented at the SOLAR 2007 Conference, Cleveland, Ohio, 12 July 2007.

135 S. Clemmer, *Strong Winds: Opportunities for Rural Economic Development Blow across Nebraska.* Cambridge: Union of Concerned Scientists. Retrieved from http://www.ucsusa.org/assets/documents/clean_energy/strongwinds.pdf.

Tax Credits

One piece of legislation that has been important in the development of the wind industry is the Production Tax Credit (PTC). Originally established in 1992, the PTC serves as a federal tax incentive to eligible wind energy projects.[136] In order for a project to be eligible for the current PTC, the turbines must be large (greater than 100 kW), and must be placed in service before 2013.[137] This subsidy exists to help provide an incentive for renewable energy, based on the capital intensity of wind farms themselves. However, there are other factors besides the PTC affecting wind development:

> "Other factors that can affect wind development include (1) state renewable portfolio standards . . . (2) U.S. electricity demand growth, and (3) the price of natural gas. State RPS policies have been the primary demand creator for wind projects, in most cases, by requiring certain utilities to source a percentage of their retail electricity sales from renewable generators."[138]

Although the same study from the Congressional Research Service indicates that there will be modest demand for new electrical capacity in the United States, it also states that natural gas prices are rising steadily, and wind energy is much more competitive when natural gas alternatives rise in price.[139]

The pending expiration of the tax credit for wind projects has actually created a short-term surge in the market for 2012. This has occurred because developers are aware that if they can finish the project before the end of the 2012 calendar year then will they be able to receive the PTC credit, even if that credit is not renewed beyond its current status. Wind energy in the United States accounts for approximately 12 GW, a record high for the industry. If the PTC is renewed or extended, estimates project that installation will be approximately double what it would be if it was allowed to expire.[140] As a result, the extension of the PTC, as well as the length of the extension is likely to be a hotly debated factor by Congress in 2013. Research indicates that:

> Generally, the shorter the extension the greater the short-term economic and employment activity as developers and investors accelerate development plans in order to qualify for the PTC incentive. . . a permanent PTC is also a policy option that may be considered, and . . . estimates indicate that such a policy may actually reduce near-term wind capacity additions.[141]

Currently, developers are creating a record year for American wind energy in 2012, projecting potentially 12 GW of total installations by the end of the year.[142] Furthermore, as we approach the latter half of 2012, most efforts will be focused on construction, installation and commission activities since there is a possibility that the PTC may not be extended.[143] This current surge may slow down the construction of new wind energy projects regardless of the existence of the PTC.[144] The PTC expired in both 2002 and 2004, and both times the wind market experienced a drop in wind project installations during the following years.[145]

In summation, there is an extensive list of potentially beneficial economic impacts that may be derived from wind energy development. At the very least, wind development provides a number of jobs and increased spending at a local level. These impacts vary based on the time, location and status of a wind farm project in a community. The personal income of landowners may increase depending on factors such as the number of turbines they have on their property and the contract they negotiate with the developer. Thirdly, despite differ-

136 Phillip Brown, Congressional Research Service, R42576, U.S. Renewable Electricity: How Does the Production Tax Credit Impact Wind Markets (2012).

137 *Id.*

138 *Id.*

139 *Id.*

140 *Id.*

141 *Id.*

142 Ethan Zindler, *Clean Energy Market Trends: US House Renewable Energy and Energy Efficiency Caucus,* Bloomberg News Energy Finance, May 9, 2012.

143 Brown, *supra* note 49.

144 *Id.*

145 American Wind Energy Association, Federal Production Tax Credit for Wind Energy: The American Wind Industry Urges Congress to Take Immediate Action to Pass an Extension of the PTC (2012) available at http://www.awea.org/issues/federal_policy/upload/PTC-Fact-Sheet.pdf.

ent forms of leases and easements, in the vast majority of situations some beneficial impact on the local economy was observed with an average increase in local household incomes.[146] Finally, the flow of revenue in the form of the property taxes has aided local economies and the level of this aid depends on the tax incentives that were granted by the community or state.

Conclusion

The impacts discussed in this chapter are just a sample of the potential impacts, both positive and negative, a wind project may have on the environment, local landowners, the community surrounding the wind projects and the country itself. As a result, it is important that landowners and communities understand some of the potential effects and impacts in order to make informed decisions as to the status of these projects.

Many of the impacts depend largely on the facts and circumstances that surround the developer, the landowners and the community. Because of this variation it is often very difficult to determine what impacts a project may have just by comparing it with past projects. In the PPM Atlantic Renewable v. Fayette County Zoning Hearing Board case, Judge Leskinen stated that "both the federal and state governments acknowledge candidly that there are many as yet unanswered questions as to the best practices for siting and operating wind power farms, and even with their massive budgets and ready access to experts cannot predict all of the impacts of wind power technology at this time.[147]

Variables that could affect the impact of a wind project include tax incentives, leasing contracts, the neighboring landowners, the availability of transmission lines, and a host of other factors that may and often do come into play. Some of these impacts could be similar to past projects and others will present new issues.

146 Champion, *supra* note 40.

147 *PPM Atlantic Renewable* at 458, 466 (2010).

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