

Powering Alberta



WHAT'S INSIDE:

A SIMPLIFIED GUIDE
TO THE ELECTRIC SYSTEM

DECIDING WHAT TO BUILD:
POWER SYSTEM PLANNING

ELECTRIC LINGO

Powering Alberta

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Volume 1 Issue 1

This publication is brought to you by the Alberta Electric System Operator, or AESO.



ABOUT THE AESO

We are a key contributor to the development of Alberta and the quality of life for Albertans, through our leadership role in the facilitation of fair, efficient and openly competitive electricity markets and the reliable operation and development of the Alberta Interconnected Electric System.

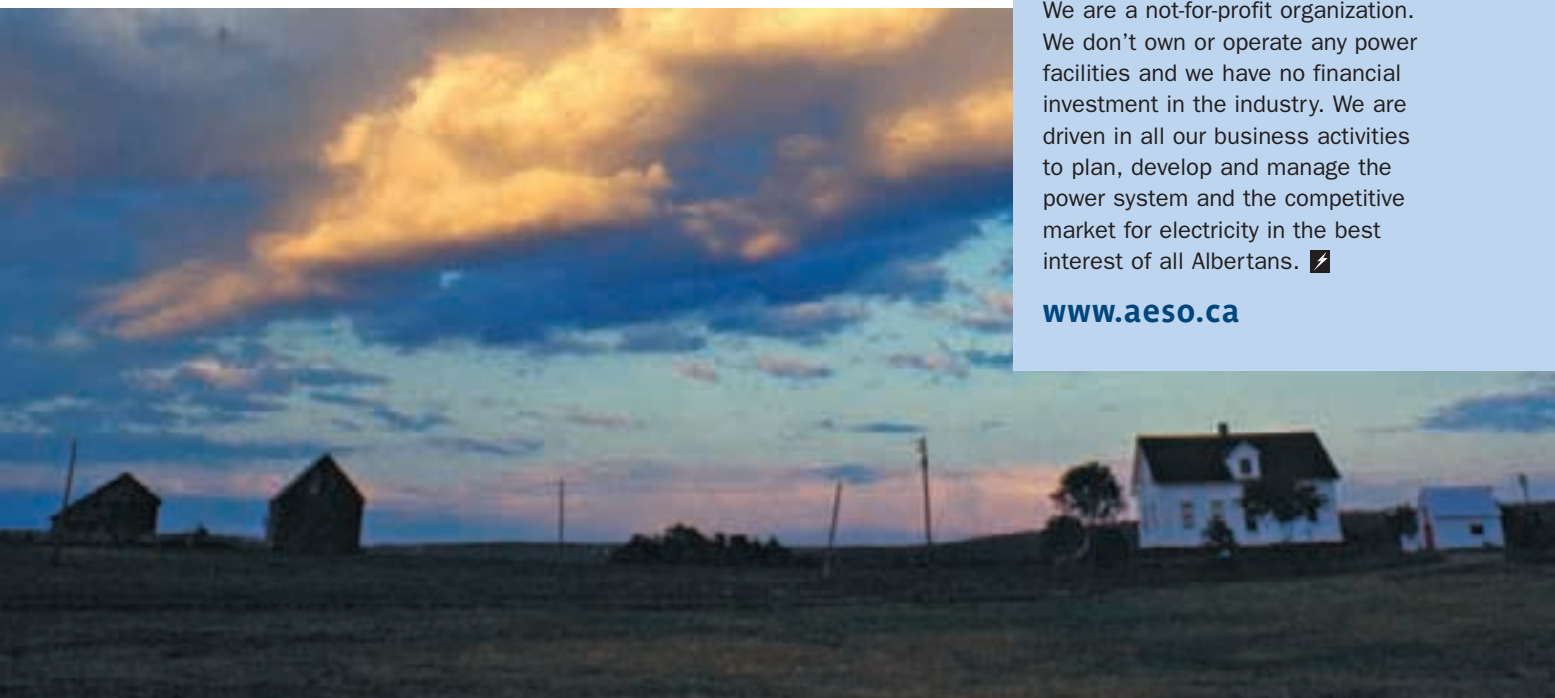
We direct the coordinated operation of the power grid, ensuring that the supply of power is in constant balance with electricity demand across the province.

We plan the provincial transmission system, including interties with neighbouring jurisdictions. We provide open access to generators and other customers who want to connect to the power system. We strive to ensure this important infrastructure is reinforced and expanded in order to keep pace with the growing demand for power.

We operate Alberta's competitive wholesale electricity market, with about 200 participants and over \$8 billion in annual energy transactions.

We are a not-for-profit organization. We don't own or operate any power facilities and we have no financial investment in the industry. We are driven in all our business activities to plan, develop and manage the power system and the competitive market for electricity in the best interest of all Albertans. ⚡

www.aeso.ca





Power FACTS

► **Escape artist**

Every year the average homeowner spends about \$40 on electricity they probably don't even know is being used. Many devices are always using power, even when they appear to be off, such as garage door openers, cordless phones, televisions, computers, DVD players and microwaves.

► **In a flash**

Electricity moves at the speed of light – that's 280,000 kilometres per second. In fact, if the Earth were connected to a power source on the moon, it would only take 1.26 seconds for that power to reach Earth.

► **Thermal dynamic**

Alberta has several large power plants that use coal to create electricity. About 70 per cent of Canada's coal reserves are found here. Coal is the most abundant and least expensive source of fuel in the province.

► **Blow me down**

Alberta was the first in Canada to develop interconnection standards for wind power and the first province to begin detailed studies on how to forecast wind patterns.

► **Nowhere to hide**

Electricity cannot be efficiently stored for long periods of time. It must be used in the same instant it is produced, which means that supply and demand must always be balanced.

► **Power costs**

Many of the modern conveniences that improve our lives depend on electricity. The following chart gives an idea of the average monthly power use and cost.



<i>Item</i>	<i>Average Monthly Power Use (kWh)</i>	<i>Average Monthly Cost @ 7.8¢/kWh</i>
Hair dryer	3.0	\$ 0.23
Compact fluorescent light bulb	4.5	\$ 0.35
Toaster	9.0	\$ 0.70
27" colour television	13.6	\$ 1.06
100-watt light bulb	18.0	\$ 1.40
Computer and printer	24.3	\$ 1.90
Dishwasher	60.0	\$ 4.68
Dryer	75.0	\$ 5.85

Sources: Alberta Department of Energy, EPCOR, Natural Resources Canada

Electricity at work

A Generating station

Power is generated using a fuel source to create a rotating motion, which is then turned into electricity. At coal-fired and gas-fired plants water is heated to create steam and the pressure spins the turbine that powers the generator. In a hydro-electric plant it is the force of falling water that creates the motion necessary to generate power. In a wind turbine it is the intensity of the wind that causes a generator to spin.

Alberta's power sources

Coal: 5,840 megawatts

Gas: 4,412 megawatts

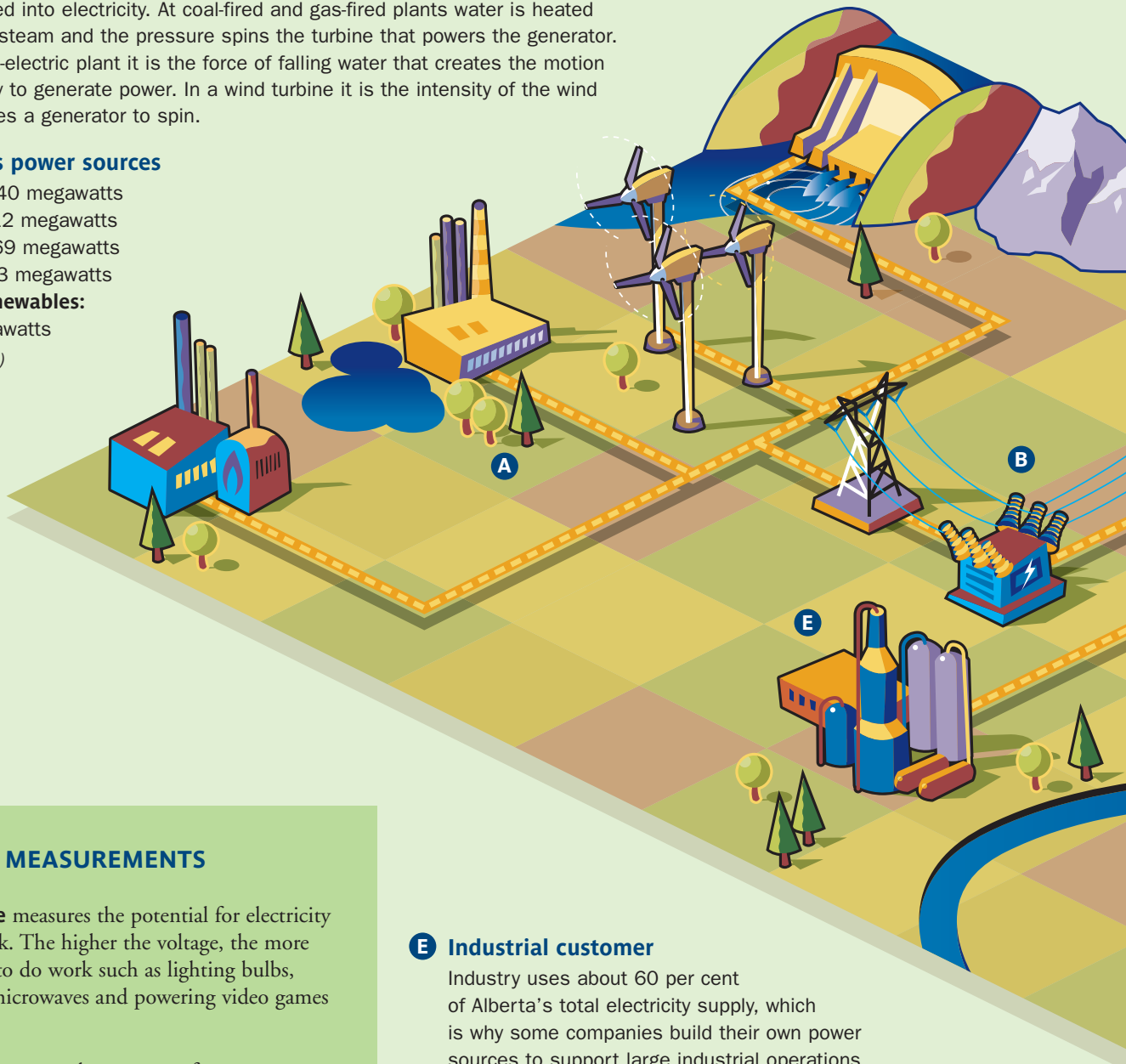
Hydro: 869 megawatts

Wind: 443 megawatts

Other renewables:

178 megawatts

(May 2007)



POWER MEASUREMENTS

► **Voltage** measures the potential for electricity to do work. The higher the voltage, the more potential to do work such as lighting bulbs, running microwaves and powering video games and tools.

► **Watts** measure the amount of power something uses. The greater the wattage, the more energy a device uses over the course of an hour. Kilowatts and megawatts are larger volumes of this basic measurement.

► **Amps** measure the flow of electric current. The current carries energy from a source of electricity to an electrical device, much like water flowing down a river. ⚡

See page 9 for other common power definitions.

E Industrial customer

Industry uses about 60 per cent of Alberta's total electricity supply, which is why some companies build their own power sources to support large industrial operations such as steel mills, forestry and petrochemical processing plants. When Alberta needs more power these industrial customers can send their extra energy onto the grid.

F Distribution substation

Power lines enter the substation through a switching device and connect to distribution equipment. A transformer reduces the voltage and the electricity is then routed to the distribution power lines that will carry it to homes, farms and businesses.

B Transmission substation

A set of large transformers increases the voltage of power coming from a generating station for its long journey through the transmission grid to customers.

C Transmission line

Towers and poles support sets of high capacity wires. Transporting power at higher voltages over long distances is best because this reduces line losses, which are essentially the energy used in transit. Typically, two to five per cent of the power entering a line is lost due to the resistance created as electricity moves along the line.

D Intertie

Connections with neighbouring electric systems act like gateways, allowing power to move in or out of the province.

F

G

H

G Distribution line

Low voltage power lines carry electricity to homes, farms and businesses.

H Power meter

The amount of electricity delivered to a home, farm or business is measured using a meter.

POWER for the people

On any given day the benefits of electric power have an influence on our lives. From the tools we use at work to the lights that illuminate our homes, practically everything we do and use today relies on electricity. It powers our lives.

Our alarm clocks allow us to get up on time. Our stoves make it quick and easy to cook meals. DVD players set the stage for family movie nights. And modern medical equipment makes assessing and treating patients far more effective. Our society has few activities that don't require electricity.



Power is so common today that it seems hard to believe the technology was not widely trusted when it was first introduced to Albertans in the early 1900s. At that time, the concept of electric power as something that could be useful was a very foreign idea. One early power company even hired nurses, because they were a trusted source of information, to travel around the province introducing people to the benefits of electric power. People were surprised at how electricity could save labour when completing common household tasks like laundry and cooking. One hundred years later we've experienced a complete shift. In fact, now we take electricity for granted.

Today the entire province is networked with a provincial transmission system or power grid that operates much like a system of highways. There are major routes that connect large centres and handle a high volume of traffic and smaller, secondary routes that branch out into every community in Alberta. In the transmission planning world, these two types of electricity highways are called the bulk and regional transmission systems. About 21,000 kilometres of transmission lines make up the Alberta system and these are supported by 530 substations that transform the electricity as it moves through the province.



Photos courtesy of Glenbow Archives.

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Originally, people were surprised at how electricity could save labour. Today, we take electricity for granted.

The transmission system is built

Many of the early power lines for Alberta's transmission system were built to connect the sources of power generation that were already in place to consumers. Most of this generation still remains in the same locations, which are primarily along the Bow Valley river system and in the Lake Wabamun area west of Edmonton.

Alberta's early transmission lines were mounted on wooden poles constructed in the shape of an "H". These lines connected the sources of power to the growing populations in central and southern Alberta. However, it was not until the 1960s, when a new coal-fired plant was built near Wabamun that a 240-kilovolt line was constructed between Edmonton and Calgary to meet the power needs of Albertans.



Growth spurt

Throughout the 1970s and '80s rapid development took place along Alberta's transmission system and the current network of power lines connecting the province started to take shape. A growing provincial economy and higher standard of living was fuelling the increased demand for electricity. Albertans began using more power as technology continued improving and the population grew. Demand across the power system increased by 10 to 15 per cent. Also, rapid developments in

It was essential to build transmission infrastructure to keep pace with demand and ensure a reliable supply of electricity for Albertans.

the conventional oil and gas industry, as well as the related petrochemical processing facilities, were key drivers of this growth.

It was essential to build transmission infrastructure to keep pace with this demand and ensure a reliable supply of electricity for Albertans. During this time several new transmission lines

were built in the province including two new 240-kilovolt lines connecting Fort McMurray to the transmission grid. Reinforcements to the power lines connecting power plants around Lake Wabamun and Edmonton were also developed.

Alberta's electricity island is bridged

A dramatic new shift in the way electricity was managed in Alberta arrived when the connections to the electric systems of B.C. and Saskatchewan were established. The new interties provided greater flexibility in operating the existing system, access to broader energy markets and the potential for imports and exports of power. For the first time it was possible to rely on our neighbours when there wasn't enough power to meet demand in Alberta. In turn, they could rely on us. The interties created new markets for selling excess power that Albertans did not need. Alberta was also able to purchase economical power supply from other markets.



Some types of power plants can be built in 18 to 24 months, but a transmission line takes between five and eight years to plan and construct.

The B.C. intertie was planned in the late 1970s and built in the early 1980s. A lower voltage connection between the two provinces did exist prior to construction of the new gateway, but provided only limited capability. The intertie is a 500-kilovolt gateway to the B.C. electric system and all the other systems that B.C. connects to along the western coast of North America and into northern Mexico.

The ability to export power on this intertie has declined over the last few years because the Alberta system has been operating at its limit. Interim measures to allow the export of power on this intertie have been introduced, but it is still operating below the original design limits. When Alberta's ability to export power is reduced it can affect things like the stability of market prices for electricity as well as the potential for development of new generation in the province. As the Alberta transmission system is reinforced, this will return the intertie to its full capacity.

Alberta's second intertie is with Saskatchewan and it was built in the late 1980s. This connection uses high voltage direct current technology, or HVDC.

Constructing the Saskatchewan intertie allowed Alberta to import and export electricity through Saskatchewan and the mid-continental market of the U.S. The intertie was initially designed to allow 150 megawatts of electricity to move between Alberta and Saskatchewan; however, because the existing Alberta transmission system has reached its operating limit, the export capacity of this intertie has been reduced by over half.

The industry is restructured

During the 1990s Alberta's electricity industry was restructured and significant changes took place. First, the generation of power was opened to competition. The retail sale of power followed in 2001. The transmission system remained regulated because it is critical public infrastructure and doesn't lend itself well to competition.

One of the most important changes for transmission was the approach to planning. Under the previous approach, decisions about new generation were normally made by the utility companies before any transmission planning began.



Alberta's new industry structure separates these activities. Today, transmission is centrally planned and designed to be in place ahead of any increases in consumer demand or any new generation development.

While this model works well to support a competitive marketplace, it does create some new planning challenges. Some types of power plants can be built in 18 to 24 months, but a transmission line takes between five and eight years to plan and construct. This means planning for transmission must be based on long-term forecasts and expectations about the most likely scenarios for new generation. Transmission system planners rely on estimates of population and economic growth as well as expectations from industry about the construction of new generation facilities.



Planning for tomorrow

Today, Alberta's transmission system is managed by the Alberta Electric System Operator, or AESO, a central transmission planner with a public interest mandate to develop and maintain the power grid for the benefit of all Albertans. The AESO has no commercial interest in any power facilities and operates on a not-for-profit basis. Its objective is to maintain safe, reliable and economic operations on the provincial power grid.

The tremendous growth of the past decade has placed pressure on the existing transmission system, which is now carrying a much higher volume of traffic.

The AESO develops three key planning documents to guide the timely development of Alberta's power grid: a 20-Year Outlook; a 10-Year Transmission System Plan; and individual Need Applications for each new project being proposed.

Using this planning approach the AESO develops integrated plans and is working hard to ensure that all stakeholders are kept current on the proposed requirements for the transmission system and consulted as plans are developed.

All transmission plans on the Alberta system are developed using a set of criteria for maintaining reliability, as established by the AESO. Using these criteria, the conditions that will put future stresses on the existing system

are identified. This allows the AESO to spot potential areas of concern so that new lines and upgrades can be built in advance of any problems.

The 20-Year Outlook takes a long-term planning view and represents the strategic direction for the system.

The 10-Year Transmission System Plan provides a roadmap for the types of projects that may be required if the most likely scenarios for electricity supply and demand unfold as forecast. Finally, a Need Application represents a specific recommendation for a particular transmission line or system upgrade. This document is submitted to the Alberta Energy and Utilities Board for approval.

The tremendous growth of the past decade has placed pressure on the existing transmission system, which is now carrying a much higher volume of traffic. While the regional system has been reinforced, there has been only one major transmission line built in the last 20 years and it is located between Fort McMurray and the Edmonton area. In the meantime, the role of power in our society has come a long way. What was once a novel and somewhat suspect technology has become so important to our daily quality of life that we hardly notice it. These days, power is so essential that its transportation must be planned in advance to ensure a safe, reliable and economic power supply is available today and in the future. ⚡



Electric lingo

The electricity industry has a language all its own. Knowing the meaning of a few key terms makes it easier to understand how the electricity system functions.



Reliability

There are two components to electric system reliability: adequacy and security. Adequacy is the ability of the electric system to respond to the demand for power from consumers. Security is the ability to withstand sudden disturbances or the unanticipated loss of facilities on the system.

Peak

The maximum amount of power used on the system in any given period of time such as a day, month or year. The peak demand is reported in megawatts and shows the amount of power necessary to serve all customers during times of high power use. In Alberta, this tends to occur during the dark and cold winter months.

Load

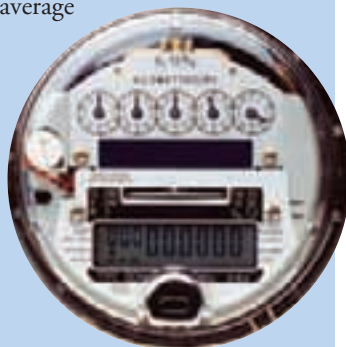
Load is essentially the demand for power on the electric system. It can be measured for an overall system, or at specific points along the electric system like at a city, town or home.

Supply – demand balance

One of the most important things to remember about electric systems is that the supply and demand for power must always be equally matched. Electricity cannot be stored efficiently and so it must be used at the same instant it is produced. If an imbalance occurs and more power is demanded than is available, a shortage, outage or, in severe cases, a blackout will occur. If more power is created than is used, the system will shut down to protect itself.

Kilowatt hour/megawatt hour

Kilowatt and megawatt hours are the measures of how much energy is being created or used over time. The amount of power consumed multiplied by the number of hours it is used creates a kilowatt hour or megawatt hour. For example, a lamp that uses a 40-watt bulb and is left on for three hours will use 120 watt hours of energy, which translates to 0.12 kilowatt hours of electricity or 0.00012 megawatt hours. The average home uses approximately 600 kilowatt hours of power each month and the average farm uses approximately 1,800 kilowatt hours per month. ⚡



Kilowatt/megawatt

Power is measured in watts. Households consume power in kilowatts, which represent 1,000 watts. Power is normally produced in large volumes called megawatts, which represent 1,000 kilowatts.

AC vs. DC

The two main types of electricity are alternating current, known as AC, and direct current, known as DC. The difference between alternating current and direct current systems is in how the power moves through the lines. With an alternating current the flow of power reverses direction – actually 60 times per second, but with a direct current the power will only move in one direction. Both technologies were developed around the same time, but alternating current has become the predominant system in use. Alberta's transmission system has been built to work with the alternating current generated at our power plants. To connect AC and DC systems a converter station must be built. ⚡

Deciding what to build

An electric system involves thousands of decisions and millions of moving parts. In fact, the North American electric system has been described as the largest and most complex machine in the world.

As part of this larger interconnected grid, Alberta's power system must be able to respond to instantaneous changes in the supply and demand for power at any given moment. As a result, transmission planners balance a long list of factors when deciding how to reinforce and upgrade the provincial transmission system in the best interest of Albertans.



Clarifying need

The basic question that the AESO's transmission planners must answer is *"How best to plan, design and develop a transmission system that connects demand for electricity to the sources that produce it?"*

In their technical analysis, transmission planners begin by looking at the structure of the existing system. While the regulation, delivery and planning of Alberta's electric system have all undergone dramatic change in the past 10 years, what has not changed are the locations of the basic infrastructure this system is built upon. Existing infrastructure has been developed to support Albertans where they currently live and connects them to existing power supplies based in a few key locations around the province. The reality is that these locations are fixed and system expansions must operate using this existing infrastructure. Transmission system plans must be flexible to accommodate new and expanding centres of demand (e.g. towns and large industrial customers) as well as new supply technologies as they are developed and connected to the grid.

Once the technical requirements of the existing system have been factored in transmission planners must also consider forecasts of how the demand for power might change in the future. These forecasts examine trends in things like projections of population in the province, gross domestic product and operations of large industrial customers. This information is then translated into forecasts for energy consumption on the electric system.

In addition, planners must be aware of future sources of generation and where these might be located. In some cases new generation sources are built by expanding existing sites, but the development of industry or fuel sources in a particular area can also create the possibility that new sources of power will be located there. All of these new sources must be carefully and reliably connected to the transmission system.

When all of this information is collected it is placed into complex computer models that mimic the function of the electric grid. This allows planners to test how the system will handle normal as well as more extreme operating conditions. Areas that might have difficulty performing under certain situations are identified and options to solve the concerns are examined.





Arriving at a recommendation

Recommending new transmission facilities to include in a Need Application can only occur after extensive analysis. Transmission planners consider a number of alternatives from the choice of technology to the voltage level to the use of double circuit structures or even underground applications. A critical input into any recommendation for new transmission facilities is feedback from the public and industry. Meaningful opportunities for consultation and open discussion occur during the planning stages and include the following topics: land use, economics and technical analysis.

Land use analysis Planners must examine land use at a high level when considering the options for new facilities. To do this the AESO's transmission planners rely on the expertise of the transmission facility owners who will operate any new facilities to ensure as much as possible is understood about the existing system and land use. Parks and other environmentally sensitive areas are avoided as well as areas with key public infrastructure such as airports. Transportation and Utility Corridors, areas identified by municipalities for infrastructure development, are considered in the analysis. Additional input through public consultation is also weighed as the options for new facilities are developed and examined. In the case of small projects, like a line connecting a new manufacturing facility to an existing transmission line, a limited analysis would be done. In the case of larger projects, like those with new lines that will travel hundreds of kilometres, a more detailed geographic analysis is completed. Generally, comprehensive land use studies are done by a transmission facility owner before they file a Facilities Application with the provincial regulator, the Alberta Energy and Utilities Board, or EUB.

Economic analysis The economic impact of the options transmission planners are recommending must also be carefully weighed. In some cases the costs to pursue a new technology or type of connection might result in high costs for consumers. The costs of constructing new facilities as well as the ongoing costs to operate and maintain them must be considered. How a system is constructed can also influence the costs to operate it. Usually a significant component of this analysis involves line losses, which are losses of power as it moves along a power line. Higher voltage lines have fewer losses as do shorter lines. The size of the wire used also has an effect on how much energy is used up in transport.


Technical analysis The way that electricity behaves places some limits on how transmission planners can connect the sources of supply and demand. Currently, there is no efficient way to store large amounts of electricity; it can only be converted into another form by being used. As a result, transmission planners must always ensure that the system is developed in a way that achieves a dynamic balance between the supply of power and its demand in both normal and extreme operating conditions.

All of this information is used in developing an application for the regulator, called a Need Application that details the necessity of building new transmission facilities and includes a recommendation to meet the need.

Considering different points of view

No analysis is completed in a vacuum and transmission planners take care to engage different stakeholders for their points of view as they develop a Need Application. Input from those in the industry, the users of electricity and those affected by new facilities are all factored into the decision making along the way.

Next steps

Once the Need Application has been considered by the regulator and the need for a new transmission line is approved, each aspect of the approved option goes on to be considered in much greater detail by the transmission facility owner. Additional consultation must take place, as well as regulatory review and approval before a route is finalized and construction can begin. 

INTERTIES:

Alberta was an electricity island until the early 1950s. Before that time the entire electric system was separate from the rest of North America, which meant we needed to produce all the electricity Albertans used.

Alberta's interties were built to import or export approximately 1,150 megawatts of electricity. This is about enough power to supply the needs of every city in the province outside of Calgary and Edmonton.

Interties play a key role in maintaining a safe, reliable and economic power system as well as an openly competitive market, but their importance can be misunderstood. Here are answers to some of the most common questions about interties.

Alberta's power gateways

WHAT are interties?

Interties are connections between separate electric systems. Normally, they consist of high-voltage transmission lines.



HOW do interties work?

Interties connect to the edge of an existing electric system and work much like a gate. The opening on that gate is controlled to manage how much energy flows through. When the gate is opened power flows in or out, depending on whether the electric system has an excess or a shortage of power to meet its current level of demand. Like other parts of a transmission system, interties are built to handle a specific volume of power. The amount of energy that moves through the intertie is limited to the capacity on the line as well as the ability of the connecting systems to supply or use the power. Other factors such as high traffic on the electric systems at either edge of the intertie can affect their ability to function as a gateway.

WHY do we need interties?

There are many reasons to have interties. They create greater flexibility for an electric system because interties allow power to be imported when the existing system does not have enough electricity to meet demand. They also allow power to be exported when there is surplus energy available. This feature is particularly helpful if storms or other emergencies have knocked out power on part of the electric system. In addition to making the system more reliable, interties also help to make the electric systems they connect to more attractive for investment. If power generators see opportunities to sell the excess power they create, they are more likely to build new facilities before there is a supply crunch. This attracts market participants and also ensures a healthy environment for the development of new technologies.



WHO operates interties?

Interties are operated as part of the overall electric power grid. The Alberta Electric System Operator, or AESO, is responsible for controlling the flow of energy through these connections, but the actual facilities are owned by separate transmission facility owners. In addition to Alberta's two existing interties there are two new projects currently being advanced in Alberta. These proposed transmission lines will be privately owned. Alberta ratepayers do not pay for these transmission lines. The AESO is responsible for determining how these transmission lines are reliably connected with Alberta's existing transmission system. ⚡



An AESO system controller monitoring Alberta's power grid.

WHEN are interties used?

The supply and demand for power within an electric system must be constantly balanced. For this reason interties do not export electricity if there is not enough power in the system to meet current demand. If there is a shortage of power, interties are used to make up the difference. For the past five years, Alberta has imported more power than it has exported, reaching a high of over one million megawatt hours in 2006.

Brighten your day

Starting at the generating stations, find the route through the maze that allows electricity to reach your house. If you reach a dead-end, simply turn around and try again.



Shine a light on the path so electricity can reach your house.

