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Issues Affecting the **Electricity Transmission and Distribution System** in North America

A White Paper

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Executive Summary

After more than two decades of underinvestment, the North American electricity delivery infrastructure is struggling to meet today's changing and ever-growing demands. This was made evident to the public on August 14, 2003, a warm, calm summer day when large portions of the Midwest and Northeast United States and Ontario, Canada, experienced a massive electric power blackout. The outage affected an area with an estimated 50 million people and 61,800 megawatts (MW) of electric load in the states of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey and the Canadian province of Ontario. The result of this event was to raise the profile of electricity delivery issues to a place of prominence on the political agendas of both the United States and Canada.

The North American transmission system, or "Grid," is a complex network of interconnected power lines that has evolved over the last 100 years, delivering needed electricity from more than 950,000 MW of generating stations to well over 100 million customers. This must be accomplished by constantly keeping the supply and demand absolutely in balance at all times while ensuring that customers can flip a switch and be certain that the electricity they need will be available.

Creating policies to keep the system working is based on striking a balance between three key drivers: adequate and reliable supply, acceptable electricity prices and environmental sustainability.

Historically, as the system was developed, vertically integrated regulated utilities were focused on delivering adequate supply and reliability, building a system of generating stations and transmission lines that would support the evolving needs of electricity consumers. Over the last two decades, there has been a trend toward deregulation of the sector, meaning the unbundling of generation, transmission and distribution. The objective was to develop efficiencies through competition and to provide broader access to lower-cost electricity generation. In this model, managing the operation of the grid has become the purview of Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs).

Reliability of the system has been managed through adherence to voluntary reliability standards established through the North American Electric Reliability Corporation. The cascading events of the 2003 blackout and the recognition that failure to meet these voluntary standards was at fault made it clear that this is no longer sufficient to meet the needs of the system. The major recommendation of the United States/Canada Blackout Task Force was to create the Electricity Reliability Organization (ERO), which would make compliance with reliability standards mandatory, with penalties for utilities that fail to meet these standards. This was legislated in the US Energy Policy Act (EP Act) of 2005, and the new ERO came into being earlier this year.

Improving the reliability of the system must also address its future needs. Electricity consumption is forecast to grow by more than 40% by the year 2030. In the United States alone, spending on transmission is growing, with an estimated \$31.5 billion to be spent by 2009. Opposition to new lines makes siting extremely difficult, and, in many cases, primarily in the United States, cost allocation is also a major issue. These two issues can and often do cause delays in transmission projects. The US government has identified a strong electricity infrastructure as essential to the country's economy. As a result, the EP Act of 2005 has put measures in place to ensure that transmission is built when needed. These measures include defining a process for the establishment of national transmission corridors and offering more attractive financial incentives to investors.



Delivering resolution of the above issues is a daunting task, and to add to the challenge, this must all be accomplished in a changing world. Environmental requirements are now causing every aspect of how electricity is generated, delivered and consumed to be questioned. Climate change is at the top of the political agenda, and electricity generation through the use of fossil fuels is a major source of greenhouse gases. The result is a strong push for new energy efficiency and demand response programs to reduce overall use and to shave the peak, while also driving the use of more environmentally friendly "green" technologies for new generation. Many of these renewable energy sources, such as wind or solar energy, have technical characteristics very different from the more traditional forms of generation. These sources tend to be non dispatchable, meaning that their contribution to the grid is intermittent and not easily controllable by the system operator. This is creating new challenges for the system moving forward.

Addressing many of these issues and moving toward the system of the future requires the use of new enabling technologies. The implementation of "smart" meters to enable time-of-use billing

and remote control devices to enable system-controlled demand response is underway and is changing the very nature of the grid. This will be followed by the implementation of a number of other new technologies in the years to come.

This century-old system is experiencing a period of transition unlike any that has been seen before. Improving the reliability of the system, while meeting the requirements for growth, all in an environment of enormous structural and technical change, is a great challenge for the future. Achieving these goals will be dependent upon having a well-trained and highly motivated workforce. Yet the current work force is aging, with about 50% eligible to retire in the next decade. Therefore, increased pressures to meet reliability standards, build new transmission and implement the technologies of the future will make workforce management much more important.



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Introduction

“On August 14, 2003, large portions of the Midwest and Northeast United States and Ontario, Canada, experienced an electric power blackout. The outage affected an area with an estimated 50 million people and 61,800 megawatts (MW) of electric load in the states of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey and the Canadian province of Ontario. The blackout began a few minutes after 4:00 p.m. eastern daylight time (16:00 EDT) and power was not restored for four days in some parts of the United States. Parts of Ontario suffered rolling blackouts for more than a week before full power was restored.”

Modern society has come to depend on reliable electricity as an essential resource for national security; health and welfare; communications; finance; transportation; food and water supply; heating, cooling and lighting; computers and electronics; commercial enterprise; and even entertainment and leisure—in short, nearly all aspects of modern life. Customers generally know little about the system that provides them with their electricity, but they do expect that electricity will be available when needed at the flip of a switch. While most customers have experienced local outages from time to time caused by an accident or severe weather, what is not expected is the occurrence of a massive outage on a calm, warm summer day. Widespread electrical outages, such as the one that occurred on August 14, 2003, are rare, but they can happen if multiple reliability safeguards break down.

The North American transmission system is a complex network that has evolved over the past century to meet the ever-growing power-hungry needs of society. The system was developed on a regional basis and expanded on a piecemeal basis, not planned in an integrated fashion across the continent. The last 20 or 30 years have seen chronic under investment in new transmission, far below investment in generation. The result is an aging infrastructure that is falling apart at the seams. With current environmental requirements and electricity deregulation changing the rules of the game, the system is being challenged as never before. And with projections of continuing growth and rapidly changing technology, huge investments are required to improve the reliability of the system today and to meet the needs of the future. Unfortunately, it can take an extreme event such as the 2003 blackout to bring this issue to the forefront and drive needed action.

In response to a request from ClickSoftware, this white paper will examine the issues faced by the electricity transmission and distribution system, including those related to the workforce, as it struggles to move forward and keep the lights on for the people of the United States and Canada.

¹ U.S. – Canada Power System Outage Task Force, “Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations”

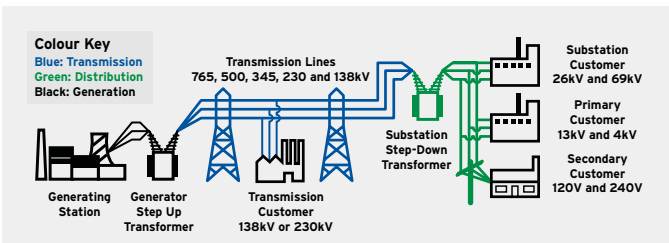


North American Transmission System

The electricity delivery infrastructure represents the culmination of 100 years of development and growth to create a complex system that must always be in balance while delivering the necessary electricity from the source of supply to the end user. This electricity infrastructure represents more than \$1 trillion (U.S.) in asset value, more than 200,000 miles (or 320,000 kilometers) of transmission lines operating at 230,000 volts and greater, 950,000 megawatts of generating capability, and nearly 3,500 utility organizations serving well over 100 million customers and 283 million people.

The system is built of a large number of generators of different types - fossil, hydro, nuclear, wind, biomass and others - producing electricity at low voltage. This electricity is then "stepped up" to high voltage for delivery over a network of interconnected bulk power lines, and then the voltage is once again lowered for distribution to final customers. This system is known as the "Grid."

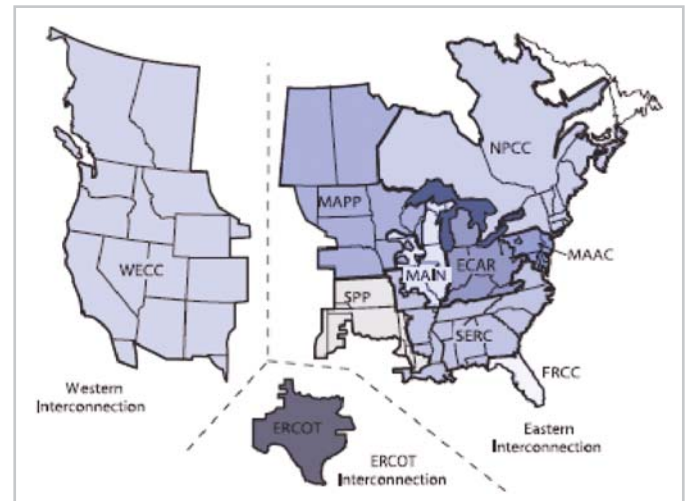
North American Electric System - Basic Structure



While customers are used to electricity always being available at the flip of a switch, in reality, maintaining the grid is a very complex undertaking that requires a real-time assessment, control and coordination of the thousands of generators, high-voltage transmission system and final distribution to customers. This is because, in comparison to all other forms of energy, electricity cannot be economically stored, so at all times, supply and demand must be in complete balance.

The North American grid is largely interconnected but is not one system. It is actually made up of three major systems. The Eastern Interconnection includes the eastern two-thirds of the continental United States and Canada, from Saskatchewan east to the Maritime Provinces. The Western Interconnection includes the western third of the continental United States (excluding Alaska), the Canadian provinces of Alberta and British Columbia, and a portion of Baja California Norte, Mexico. The third interconnection comprises most of the state of Texas. In general, these three systems are completely independent of one another, with only some minor DC connections between them.

The North American Grid and Its Interconnections



Even though the grids are primarily interconnected in a north / south flow from Canada to the United States, there remain many differences in policies between the two countries. In the United States, electricity policy is established at the federal level and is regulated by the Federal Energy Regulatory Commission (FERC). The systems are then managed on a regional and local level by individual utilities and market operators, which must meet the requirements of public utilities commissions. In Canada, electricity is the responsibility of the provinces and each province has its own policies and regulations. There is little to no federal involvement in the electricity sector.

² U.S. -Canada Power System Outage Task Force, "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations"

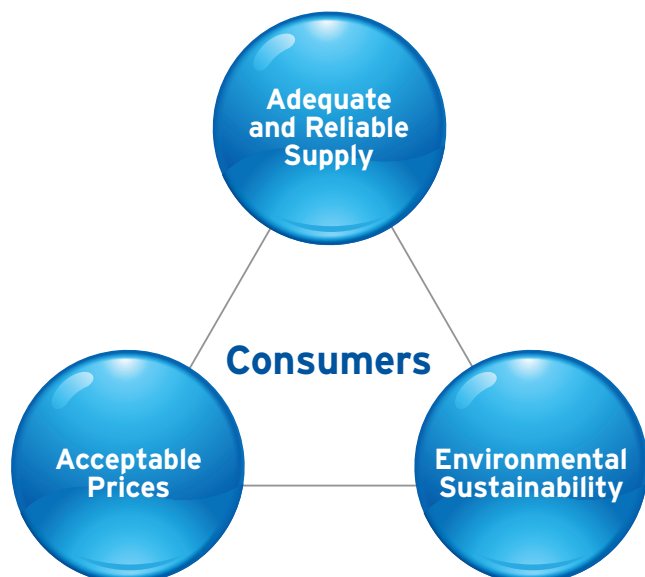
Key Drivers Affecting the Electricity System

Electricity policy is generally determined as a result of striving to satisfy three key drivers: adequate supply and reliability (technical), acceptable prices for customers (commercial) and environmental concerns (social).

This was achieved in the past through the use of relatively large, vertically integrated utilities that were responsible for all aspects of electricity supply: generation, transmission and delivery to customers. These companies operated in a defined service territory and had an obligation to serve. The objective was to build a strong, stable system that would assure adequate, reliable electricity supply at the lowest possible cost. Consumers would pay regulator-approved prices based on cost of service. Environmental requirements were met through adherence to regulations regarding discharges of pollutants to air and water.

Keeping a balance between these drivers is an ongoing challenge for policy makers and regulators, as often, these drivers can be in conflict with one another. Overall, in North America, the low cost of electricity has been a major contributor to industrial and commercial development. Supply and reliability can always be improved by increased investment, but at a higher cost to consumers. Reducing environmental impacts also drives the system to add higher cost, but lower emitting sources of supply.

Electricity System Drivers



Keeping a balance between these drivers is an ongoing challenge for policy makers and regulators, as often, these drivers can be in conflict with one another. Overall, in North America, the low cost of electricity has been a major contributor to industrial and commercial development. Supply and reliability can always be improved by increased investment, but at a higher cost to consumers. Reducing environmental impacts also drives the system to add higher cost, but lower emitting sources of supply.

Traditionally, the emphasis has been on meeting technical requirements to ensure an adequate and reliable system. More recently, commercial requirements have become more important and have resulted in deregulation to promote competition and provide broader access to lower supply costs. Currently, environmental issues are now having far-reaching effects on the system as a whole that are driving major changes which will dramatically affect the way the grid looks in the future.

Deregulation

More recently, to make the system more efficient and lead to lower costs, many jurisdictions have decided to introduce competition through deregulation. This was achieved by unbundling the services into generation, transmission and distribution and by allowing customers to choose their provider, at both the wholesale and retail levels. The system is then managed by Independent System Operators (ISOs), which operate the market.

As part of this restructuring, transmission systems have remained regulated, due to the recognition that there is a need to make sure the infrastructure is capable of delivering the electricity. This is being done by the creation of Independent System Operators. Wholesale access to transmission grids enables local distribution companies, or other large buyers, to use the grid to purchase electricity from the most competitive generation sources. Since the issuance of Order 2000 in 1999, the FERC has promoted the formation of Regional Transmission Organizations (RTOs) as the mechanism to achieve wholesale access, thus enabling US consumers to obtain lower-cost power from other regions. Finally, retail access could economically benefit consumers as a result of their having choice among suppliers.

British Columbia Energy Plan Zeros in on New Greenhouse Gases

The new BC Energy Plan: A Vision for Clean Energy Leadership puts British Columbia at the forefront with aggressive targets for zero net greenhouse gas emissions, new investments in innovation and an ambitious target to acquire 50% of BC Hydro's incremental resource needs through conservation by 2020. Among the highlights:

Environmental Leadership:

- All new electricity projects developed in BC will have zero net greenhouse gas emissions.
- Existing thermal generation power plants will reach zero net greenhouse gas emissions by 2016.
- Achieve zero greenhouse gas emissions from coal-fired electricity generation.
- Clean or renewable electricity generation will continue to account for at least 90% of total generation, placing the province's standard among the top jurisdictions in the world.
- Eliminate all routine flaring at oil-and-gas-producing wells and production facilities by 2016 with an interim goal to reduce flaring by half (50%) by 2011.
- Achieve the best coalbed gas practices in North America. Companies will not be allowed to surface discharge-produced water, and any reinjected produced water must be injected well below any domestic water aquifer.

Energy Conservation and Efficiency

- An ambitious target to acquire 50% of BC Hydro's incremental resource needs through conservation by 2020.
- New energy efficiency standards will be determined and implemented for buildings by 2010.

Source: BC Ministry Web Site Feb 27, 2007

Deregulation has been successful in jurisdictions with adequate supply, primarily by increasing the efficiency of existing assets. However, one of the major issues associated with deregulation is that there is no longer an obligation to serve since the assumption is that market-pricing mechanisms would ensure adequate supply. The result has been somewhat less success in creating appropriate and timely incentives to build new generation. This has had an adverse effect on meeting adequacy of supply and reliability requirements. Markets continue to evolve to meet the ongoing needs of the system.

Global Warming

Concerns about the environment and pollution have long affected the choice of generation options and have increased the costs of generation, such as coal, as pollution abatement equipment has been added to plants.

At the present time, there is no greater driver to change in the electricity system than the environment. Environmental issues and, in particular, global warming have leapt to the top of the global agenda. A Movie and presentations on global warming have made former US Vice President Al Gore into a modern cult icon. Recent reports by Stern in the UK and the IPCC have removed any doubt as to the importance to the planet of global climate change and the need to take immediate and decisive action.

Global warming is a result of greenhouse gases entering the atmosphere from burning fossil fuels. This comes primarily from two major industries: transportation and electricity generation. Since it is feasible to generate electricity without burning fossil fuels through the use of renewable energy sources, including wind, hydro and biomass and nuclear power, there is considerable pressure on the electricity industry to reduce its emissions of Greenhouse Gases (GHGs).

Both the International Energy Agency World Energy Outlook 2006 (WEO) and the US Department of Energy's Energy Information Administration (DOE EIA) Annual Energy Outlook 2007 (AEO) Reference Case clearly show that continuing down the current policy path will lead to increased use of fossil fuels over the next 25 years, with resultant accelerating increases in carbon dioxide emissions. The WEO then goes on to state that this result is not set in stone and that in an alternate policy scenario, the policies and measures that governments are currently considering to mitigate carbon emissions are assumed to be implemented. The result is significantly reduced fossil fuel demand and associated emissions.

It would seem that almost every day, a government or government agency is announcing new measures to protect the environment. California has already introduced measures to reduce greenhouse gases. More recently, the government of British Columbia announced its "zero emissions" energy plan (see box). And many more announcements are imminent.

Security of Supply

The need for oil imports from the Middle East has shown how vulnerable America is to what it considers very unstable political and potentially anti-American regimes. Since September 11th 2001, this has added the issue of security of supply to energy considerations. The result of this concern has been policy incentives in the EP Act of 2005 by the administration that emphasize energy independence. These include renewal of the use of nuclear power and considerable emphasis on continued use of coal, a dirty but domestically plentiful resource. Considerable research funds are being invested in new coal technologies, such as “clean coal” and carbon sequestration, to enable coal to continue to be used, but in a more environmentally friendly manner.

On the other hand, Canada has been blessed with almost limitless energy resources, and the current government is very focused on developing Canada as an “energy superpower,” in part to help meet the ever-growing needs of the United States. The multitude of energy choices available in Canada has led to significant regional differences; Alberta is moving forward with research into new clean coal technologies while Ontario is committing to shutting down all coal-burning facilities at the earliest opportunity.



Reliability - Keeping the Lights On

Electric reliability means continuity of service and acceptable power quality. North Americans have come to expect a very high level of reliability from the electricity system. Occasional blackouts and / or brownouts are unacceptable to consumers. The expectation is that when the switch is turned on, the lights will come on, all the time.

Poor system reliability imposes significant economic consequences on society. Estimates of the total costs of the 2003 blackout in the United States range between \$4 billion and \$10 billion (US dollars). In Canada, gross domestic product was down 0.7% in August, there was a net loss of 18.9 million work hours and manufacturing shipments in Ontario were down \$2.3 billion (Canadian dollars).

Public safety is at risk, as without power, controls of essential systems (e.g. Traffic lights, public transit, hospital emergency services, etc) are lost. A large outage in the cold winter months can leave many freezing in the dark. Many industries are dependent upon large-volume, reliable power to drive their factories and processes. Concern over the reliability in a given area can drive businesses to locate to areas that have more reliable systems, thus greatly impacting local economies.

Reliability has two key aspects. The first is adequacy of supply, which means having enough generation and transmission capacity to meet system need. The second is short-term or operating reliability, which requires the system to withstand disturbances or contingencies and be able to continue to operate when there are problems with the infrastructure or interconnected systems.

The National Electricity Reliability Corporation (NERC) is an industry organization that draws upon the technical expertise of its members. NERC has ten regional councils, comprising about 140 control areas in Canada, the US and the northern Baja region of Mexico. Most Canadian electric utilities/system operators that have interconnections with other regions are members of NERC's regional councils.

Why must there be a crisis to improve reliability?

Prior to the August 2003 blackout, much of the attention being paid to the electricity industry was related to generation and the alternatives available to meet demand. The emphasis was on deregulation as a means to create competition to both increase efficiency and bring down costs.

The blackout created the crisis necessary to get political focus on the deficiencies in the grid. And it made it clear that the system must be improved. A joint US/Canada task force studied the event for one year and concluded that lack of adherence to voluntary reliability standards by operators working to manage the aging infrastructure was the primary cause.

Its major recommendation was to create an Electricity Reliability Organization (ERO), which would make compliance with reliability standards mandatory, rather than voluntary, as is currently the case with NERC standards.

One year later, in 2005, this recommendation was enacted in legislation in the EP Act of 2005. And now, after approving NERC as the ERO in July 2006, the new ERO has started operations as of January 2007, some four years after the event.

It is interesting to note that it was another crisis, the big blackout of 1965, that resulted in the creation of NERC (in 1968) and management of the reliability of the system.

NERC's stated mission is "to ensure that the bulk electric system in North America is reliable, adequate and secure." Toward that end, the organization develops planning standards and operating policies, which are the main methods it employs to achieve reliability. However, in the past, its standards and policies were voluntary and were enforced by peer pressure.

In July 2006, FERC designated NERC as the ERO under section 215 of the Federal Power Act, a new provision added by the Energy Policy Act of 2005 to establish a system of mandatory, enforceable reliability standards under the Commission's oversight. The ERO will manage reliability by proposing standards, which are to be

³ U.S. -Canada Power System Outage Task Force, "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations"



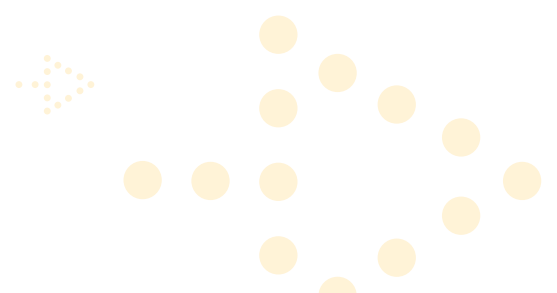
approved by FERC, and then to enforce these standards and levy fines for non-compliance, subject to FERC approval. Most Canadian provinces have negotiated participation so that there will be clear, continent-wide reliability standards and enforceability.

On average, most customer outage incidents are due to distribution system problems. Some of the most common causes of distribution outages include scheduled outages, loss of supply, tree contact, lightning, defective equipment, adverse weather and the human element. These results suggest that, from the consumer viewpoint, the reliability of the bulk power system is somewhat higher than that of the distribution system.

This is consistent with the general view that the flexibility in the bulk delivery system enables system operators to compensate for contingencies. For example, if a generating unit experiences a technical problem and must shut down, the system operator can call on reserve margins to meet demand. If a transmission line trips off, the power can flow across different lines so that demand is still satisfied in each area. In the absence of exceptional circumstances, consumers will not be aware of the disturbance. However, when larger bulk system outages occur, they affect more people and tend to last longer, as demonstrated by the 2003 blackout.

Distribution systems, on the other hand, have less flexibility because they have less redundancy built into them. The cost of duplicating the infrastructure would be high and as disturbances on these systems do not affect as many people, the benefits would be small. A lack of redundancy and generally longer distribution lines also mean that rural consumers experience lower reliability than urban consumers do. This puts added pressure on distributors to be able to respond to outages and take corrective actions quickly.

So how is reliability enhanced? Primarily through investment in new generation and transmission to build a stronger system or by reducing demands on the system in some other manner.



Enhancing and Expanding the Power Grid - Building New Transmission

System improvements and expansion are required to continue improving the reliability of the existing system, replace aging infrastructure and accommodate electricity demand growth. The US DOE EIA Annual Energy Outlook 2007 Reference Case forecasts an annual growth rate in electricity consumption of 1.5% per year, for a total increase of 43% by 2030. Growth rates in the Canadian provinces are projected to be somewhat similar. And all of this increase cannot be accommodated without increased transmission infrastructure.

As a result, investment in transmission is continuing to increase at a very rapid rate. Looking across the continent, major plans to add transmission and distribution infrastructure is universal.

US EP Act of 2005 Designates National Corridors

The EP Act of 2005 directed the secretary of energy to conduct a nation-wide study of electric transmission congestion by August 8, 2006. Based upon the congestion study, comments thereon and considerations that include economics, reliability, fuel diversity, national energy policy and national security, the secretary may designate "any geographic area experiencing electric energy transmission capacity constraints or congestion that adversely affects customers as a national interest electric transmission corridor."

Now that this study is complete, the DOE expects to open a dialogue with stakeholders in areas of the nation where congestion is a matter of concern, focusing on ways that congestion problems might be alleviated. Where appropriate in relation to these areas, the department may designate national interest electric transmission corridors.

Source: US DOE National Electric Transmission Congestion Study, August 2006

In the United States, spending reached \$5.8 billion in 2005, an 18% increase from the previous year. And spending is anticipated to continue to grow, with \$31.5 billion planned to be spent by 2009. In addition to transmission, accommodating both the significant replacement needs of the aging distribution infrastructure and

continued growth will require that \$14 billion be spent on average over the next ten years.

In Canada, Ontario has issued a draft plan showing a need for spending in excess of \$4.5 billion in transmission and distribution, and British Columbia is planning to spend \$3.2 billion over the next ten years. Both jurisdictions have identified that transmission investment is the highest priority to protect the integrity of the system in the short to medium term.

Building new transmission lines is anything but easy. Lines can cover long distances and pass through many communities, which all have a say in their approval. Although the objective is to minimize the impact on the community, explaining the benefits and necessity of the project to community members is complex, and in many cases the benefits of the project can be outside of the community being impacted. Therefore, project delays are almost inevitable during the planning stages as transmission companies work to address the issues of siting and cost Allocation. This can create considerable pressure to reduce build times once approvals are secured.

Siting

In most cases, building transmission is more difficult than building new generation as there are frequently several alternatives for routing (siting) the line. When it comes to transmission projects, there is a very strong NIMBY (Not in My Back Yard) factor. In fact, there is a whole industry associated with working with communities to fight new projects of this type. It has become increasingly difficult to site new projects, as many opponents are now working according to the BANANA (Build Absolutely Nothing Anywhere Near Anyone) principle.

Since these power lines pass over long distances, many communities are affected. It is thus not always simple to demonstrate the benefit of a new transmission line to a local community. Often the benefit is construed to be too far away for communities that are in need of this new system link.

Many regulators in the United States have clear siting rules and policies in place. This, coupled with strong utility community relations programs, definitely helps to get approvals in a more timely fashion. And new policies in the EP Act of 2005 are also designed to facilitate new build transmission projects (see section on strengthening interconnections below).

In Canada, siting issues can be even more difficult, as distances can be even longer and most transmission projects will pass through aboriginal lands. The project sponsor must then secure an agreement with each band whose land the project will impact. In some projects, this can mean 50 or more agreements, any one of which can stop the project.

Cost Allocation

In the United States, new projects often go beyond the territory of one regulator. Regulators frequently have no hard and fast rules on cost allocation and usually address these issues on a case-by-case basis. This can create delays in project implementation, and unpopular rulings may make a project not viable.

In Canada, since most transmission does not cross regional lines, cost allocation is not an issue. It is within the responsibility of the provincial regulator to approve the costs and allocate them to the rate base.

Strengthening Interconnections

Historically, the electric systems in North America were vertically integrated and each was responsible for a given territory. Whether companies were public or private, they focused on providing service to their customers in their regulated service territories. External trade and energy transfers were of secondary concern.

One of the factors influencing electricity sector deregulation was that many customers in the higher cost regions of the United States had no access to lower-cost electricity from other areas. To address this issue, since the issue of Order 2000 in 1999, the US Federal Energy Regulatory Commission (FERC) has promoted the formation of Regional Transmission Organizations (RTOs) as the mechanism to achieve this wholesale access. The structure is intended to promote competition by providing non-discriminatory access to transmission within the RTO area and to eliminate excessive transmission use charges to reduce costs.

It is generally accepted that increasing interconnections also increases system reliability, as it makes the system more flexible to accommodate faults. On the other hand, as seen in the 2003 blackout, the risks can also be higher, hence the need for more stringent reliability standards, as the system will only be as strong as its weakest link.

Improvements in interconnections will also result in less congestion. While congestion is not a result of deregulation, the unbundling of the system has highlighted the need to address it. In the EP Act of 2005, the US government acknowledged the importance of a strong national grid, and therefore mandated regular congestion studies and created the opportunity to create national electric transmission corridors (see box) to enable new transmission in areas where there is a need to reduce congestion. In addition, the EP Act has directed FERC to establish, by rule, an incentive-based rate treatment for the transmission of electricity in interstate commerce by public utilities to benefit customers through increased reliability and reduced congestion.

In Canada, regulating and authorizing the construction and operation of international power lines and designated inter-provincial lines under federal jurisdiction is the responsibility of the National Energy Board.

An East-West Grid in Canada?

Regional integration of the electric transmission grid is relatively strong, with most Canadian electricity connected and flowing in a north-south direction. In Canada, electricity is under provincial jurisdiction and the amount of interconnection across provinces is relatively weak.

Following the 2003 blackout there has been considerable interest in improving the east-west connections and further integrating the Canadian grid. This has substantial difficulties, as the distances are very long, meaning that integration would be costly and stability would be difficult.

However, there has been good progress in the consideration of new, broader east-west regional connections. Ontario and Quebec are improving their interconnection, and there are proposals to greatly improve the interconnections between BC and Alberta.

In March 2007, the federal government announced that more than \$500 million of investment through its eco trust is earmarked to support Ontario's initiative to create an interconnection with Manitoba.

Non-Wire solutions

Not all solutions for improving reliability and increasing the flexibility of transmission systems require new investment in transmission. Transmission is only one corner of a triangle in which all elements have to be in balance to create a strong, reliable system. The others are generation and demand management.

When looking at the need for a new transmission project, consideration must be given to alternative solutions. One is to provide new generation closer to the loads. This is becoming increasingly difficult in the deregulated environment, as locating generation facilities is not easily accomplished. However, even in open markets, market operators do have the flexibility to offer incentives to generators that locate in areas that improve the reliability of the overall system.

Of increasing interest is the ability to control demand. It is becoming widely accepted that the lowest-cost KWh is the one not generated. In the past, demand-reduction programs have been difficult to implement, as utilities saw little benefit in spending money to reduce their overall revenues. Therefore, it has become increasingly important to ensure that programs are well defined so that regulators will allow the cost of these programs into the rate base.

The benefit of demand-reduction programs is that they tend to satisfy all three key drivers affecting the electricity system. Demand reduction increases supply adequacy and reliability, reduces total cost to consumers and positively impacts the environment. In fact, it is the environmental benefits that are driving strong interest in these programs today. Increased efficiency is the only source of supply that has zero environmental impact. The US EP Act of 2005 places significant importance on energy efficiency through mandating improved standards and providing incentives for energy efficiency programs.

There are two types of demand reduction. In Demand Management (or efficiency) programs, the total usage of electricity is reduced, and in Demand Response programs, the emphasis is on reducing usage during peak times through either temporary reductions in load or shifting loads to off-peak hours.

It is interesting to note that in Canada, the term “conservation” continues to be used, while in the United States the term “efficiency” is more prevalent. While they have the same objectives, the connotations are considerably different. “Conservation” still has the connotation of some level of sacrifice or doing without – as in turning down the thermostat and wearing a sweater. On the other hand, “efficiency” is all about technology and achieving the same level of comfort with less. In any case, there are as many efficiency programs in place as there are jurisdictions. In fact, lack of uniformity and local and regional differences in programs are cause for concern as they have the potential to dilute the benefits of these programs and, in some cases, cause customer confusion. Most programs to reduce usage are focused on improving energy efficiency standards for various types of equipment and then providing incentives to encourage their rapid assimilation into society.

What is new is the increased emphasis on demand response, or peak shifting. This has the most impact on transmission issues, as reducing demand at peak times reduces congestion so that new transmission can be deferred or cancelled altogether. Deregulated markets have provided new ways to address this concern. For the first time, pricing mechanisms are being used to try to change customer behavior.

This is now possible due to the availability of technology to implement these programs. For example, implementing time-of-use pricing to encourage time shifting of load requires metering that can provide the data to utilities on time of use. Other programs, in which automatic controls are put on large appliances such as air conditioners so that utilities can cycle them off remotely at times of peak demand, are also possible. Customers who opt for such programs are offered pricing benefits. In the past, there were no technologies in place to enable programs such as these.



New Challenges to the Transmission Infrastructure

The requirements for new transmission to replace aging infrastructure, improve reliability and meet the ever-increasing growth in electricity demand are certainly enough to stress the system in terms of resources, both financial and human. However, this is not all. From deregulation causing uncertainty in generator type and location, to increased use of renewables with inherent characteristics that have not been experienced on the grid before, to the rapid change and requirement for new technologies, the key strategies in place to address the key drivers in Section 3 place new and previously unknown challenges on the system.

Independent Power Producers

In the many deregulated markets throughout North America, there are many independent power producers. Generators build and connect to the grid depending upon the type of fuel and the nature of their generation. In some markets, they may be totally merchant plants, and in others long-term Power Purchase Agreements may be acceptable.

Different generators can connect to the grid from different locations. This puts added stress on transmission planning, as planners do not know the locations of all the future generation in advance. This means that more robust transmission is required to accommodate the many possible generating locations. Of course, the price of connecting to the grid will have to be included in the costs of the generator, making poor locations more expensive than good ones. But on the other hand, there is no certainty that locations very important to the system will end up with appropriate generation.

There is also no certainty in the type of generation being added to the grid. A nuclear plant's technical operation characteristics differ from those of a gas-fired plant or a wind farm. The new grid must take all these things into consideration.

Growth of Wind Generation in North America

Wind generation continues to grow in both Canada and the United States.

By more than doubling its total installed capacity to 1,460 MW by year end 2006, Canada became the world's 12th largest nation in terms of installed wind energy capacity. Provincial governments are currently seeking to put in place a minimum of 10,000 MW of installed wind energy capacity

The US wind energy industry installed 2,454 (MW) of new generating capacity in 2006, an investment of approximately \$4 billion, making wind one of the largest sources of new power generation in the country – second only to natural gas – for the second year in a row. New wind farms boosted cumulative US installed wind energy capacity by 27% to 11,603 MW.

Source: American and Canadian Wind Energy Associations

Renewables and Distributed Generation

Environmental concerns have led to a very significant political commitment to new renewable resources. The EP Act of 2005 and the energy plans of the individual states and Canadian provinces all provide renewable incentives, either through the tax system (such as production tax credits) or through incentives by use of either (or both) renewable obligations and feed-in tariffs. The US DOE EIA Annual Energy Outlook Reference Case forecasts that renewable generation will increase by 1.5% per year to 2030, or by 45%. However, it acknowledges that new strategies to address global warming will likely put pressure on this number to increase. In its World Energy Outlook, the IEA recommended that the United States increase its share of renewables to achieve the alternative policy scenario.

Specifically, the US EP Act promotes renewable energy resources, including hydropower. It extends through the end of 2007 the tax credit for wind, closed-loop and open-loop biomass facilities, geothermal, small irrigation power, landfill gas and trash combustion facilities. There are increased tax credits for solar energy, and new tax credits for fuel cells and distributed generation.



The main renewables being implemented are wind, solar, biomass and hydro. Of these, only large hydro and biomass are the traditional dispatchable type of generation that can be controlled as required by the system. Renewables such as wind, solar and, in some cases, small hydro, are non-dispatchable or "intermittent" resources. This means that they are not necessarily available when needed by the system, but rather when the resource is available, such as when the wind blows or the sun shines. This has profound effects on the management of the bulk electric transmission system. It has effects on system stability and changes the requirements for system reserve allowances and standby capacity. In most systems, these forms of generation are run as "base load," meaning that they are dispatched first, or, in this case, whenever available. This may displace more economic generation, thus increasing electricity costs. ISOs are now starting to understand how to integrate this form of generation into the grid. Many studies have been done to investigate the impact of this on the system and to set targets for maximum tolerable amounts of this type of generation.

In addition to their intermittency, these resources are not transportable to a specific site, i.e., the generation facility must be built where the resource is. Once again, this places new challenges on the system, as often the best wind can be long distances from the required load. And given that it can come on and off the grid at somewhat unpredictable rates, this will have an impact on the system design and management.

The above applies to larger-scale facilities, such as wind farms. Renewable generation is also more amenable to more local or distributed generation. For example, individual homes or businesses can install solar panels or small wind turbines on their roofs, which would contribute electricity to the grid at some times; at other times their homes would be required to use grid-based power. This means new challenges for the distribution systems as customers can now also be generators.

Smart Meters and Other Technology Advancements

As discussed earlier, there are many changes in the ways that electricity is being generated, controlled and paid for. All of these changes require technology to enable them.

In order for prices to be used to influence behavior, it is essential to monitor electricity usage as a function of time. Only then can policies be put in place to charge for time of use. The technology to achieve this objective is known as "smart metering." This requires a large-scale change from the current mechanical bulk meters that are used to measure electricity usage to new electronic "smart" meters. There is no one specification for these meters. In general, they can measure, maintain and transmit usage data to the utility automatically on a frequency of interest to that utility.

Smart meter implementation is now rampant. The EP Act of 2005 requires each electric utility to provide each of its customer classes, and individual customers at their own request, a time-based rate schedule. In addition, the Act goes on to specify that each electric utility shall provide each customer requesting a time-based rate with a time-based meter capable of having the utility offer this rate structure. As a result, most jurisdictions within the United States are either implementing or have plans to implement smart meters. In Canada, Ontario has mandated that all consumer bulk meters be changed to smart meters by 2010 (4.3 million meters), with the first 800,000 meters to be installed before the end of 2007.

Smart meters themselves do not change behavior. Achieving the desired result is a function of the program design. The cost of implementing the new meters is significant, and the demonstrated net cost savings to the consumer must be real and measurable within a reasonable time frame. There are as many programs as there are utilities, and a large number of papers describing how to go about and how not to go about offering time based rates. The extent to which prices must vary from time to time to encourage behavioral change remains unclear. While there is considerable hope for this program, at this stage of its implementation, the level of success remains uncertain.

The grid is a complex, interconnected system, but it is one where there is a one way flow – from generation to final users. This is no longer the case as small generators are added to customer locations so that at some times of the day they can be users, and other times, producers. This is the case when customers install their own small generation so they can either send electricity to the grid or accept electricity from the grid, depending upon circumstances at the time. Smart meters are also required to enable this "net metering."

Other technologies are now being implemented for the purpose of demand response. For example, utilities are installing remote controlling technology so that the utility can control equipment and take it out of service during times of peak demand if supply is at risk.

A typical demand-response system would have a peak-saver switch installed on a central air conditioner. During critical times (typically on hot summer days), a signal can be sent to cycle the system down to reduce the amount of electricity it uses. No change in temperature would have been noticed. Typical activation would occur when the electricity supply was reaching its peak, usually on hot summer weekdays between 2 p.m. and 6 p.m. The activation period would not exceed four hours. Yet the benefit to the system is dramatic. Since air conditioning loads are the largest contributor to the summer peak, widespread use of this technology would reduce congestion and the need for additional generation and transmission.

As the grid evolves into the grid of the future, two-way communication will be required to remotely control loads to help manage the system. High-quality up-to-the-minute information will assist customers, generators and utilities in taking the necessary actions to keep the system running smoothly.

There are also several new technologies on the horizon for future implementation to the transmission network. The US EP Act of 2005 provides incentives for a large range of technologies: from high temperature lines to underground cables, from new transmission component materials to wireless power transmission and new electricity storage technologies.



Workforce Issues

Underinvestment in the transmission and distribution system over the last 20 years has led to an equivalent loss of opportunity to develop and maintain the work force.

The work force is aging and retirements are looming. A 2004 study by the Canadian Electricity Association noted that workers between the ages of 40 and 54 make up nearly two-thirds of the total workforce. For trade-related occupations, over one-quarter of employees were 50 years of age or older. And of more concern, only about 7% of the workers were less than 30 years old. The transmission sector had the most employees eligible to retire, with almost 30% eligible within five years, and 50% within the next ten years. This is two-thirds higher over the next 5 years than the total electricity sector average.

This would be the case if the sector were expected to be stagnant. But as has already been seen, investment in new infrastructure is expected to grow significantly over the next 25 years, meaning that there is a looming shortfall in workers on the horizon unless immediate action is taken.

Retirement is seen as the number-one work force issue by electricity sector companies. Retirement has implications much broader than simply a worker shortage. As workers retire, they take experience and knowledge with them that, without planning and training, can be lost to the utility.

Previous sections of this report have discussed the transformation in technologies in the electricity sector. Application of these new technologies will put added pressure on the field workforce. New skills will be required to meet the needs of the technology. Working on renewable technologies, such as wind or solar, requires new and more multidisciplinary capabilities to keep them running reliably.

More complex interactive systems will mean that more worker knowledge will be required to work on these systems. Training will have to be increased and workers with new and different skills will have to be added to the mix.

Implications for the workforce

The implications for the workforce are clear. New mandatory reliability standards will impose more rigorous requirements on field maintenance and times required to return system faults to service. This, coupled with a shrinking work force and added technical requirements, means that there will be a need to ensure that the right workers are at the right place to do the right work in the shortest period of time. Therefore, powerful workforce management will be a necessity to keep the system up and running reliably.

⁴ Keeping the Future Bright, 2004 Canadian Electricity Association Human Resource Sector Study



Appendix: Glossary of Terms

The following are terms used throughout this document.

Annual Energy Outlook (AEO) – Report prepared by the US Department of Energy's Energy Information Administration on an annual basis to project the trends in energy in the United States. The AEO 2007 predicts trends to 2030.

BANANA (Build Absolutely Nothing Anywhere Near Anyone)
– Term used to define opposition to projects.

Demand Management – Program to reduce electricity usage through conservation, improved efficiency or other means.

Demand Response – Program to reduce demand during peak periods through a signal by the system to the customer. Reduction can be automated or manual.

Electricity Policy Act of 2005 (EP Act 2005) – US legislation passed in 2005 defining current United States energy policy.

Electricity Reliability Organization (ERO) – Organization to manage reliability by proposing standards, which are to be approved by FERC, and then to enforce these standards and levy fines for non-compliance, subject to FERC approval.

Energy Information Administration (EIA) – Department with the US Department of Energy (DOE) that is responsible for collecting official energy statistics from the US government.

Federal Energy Regulatory Commission (FERC) – The agency that regulates and oversees energy industries in the economic, environmental, and safety interests of the American public.

Grid – The electricity transmission and distribution delivery system.

Independent System Operator (ISO) – The market operator in deregulated markets.

International Energy Agency (IEA) – This agency acts as energy policy advisor to 26 Member countries in their effort to ensure reliable, affordable and clean energy for their citizens. The IEA conducts a broad program of energy research, data compilation, publications and public dissemination of the latest energy policy analysis and recommendations on good practices.

Intergovernmental Panel on Climate Change (IPCC) – Recognizing the problem of potential global climate change, the United Nations established the Intergovernmental Panel on Climate Change to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of the risk of human-induced climate change, its potential impacts and options for adaptation and mitigation.

National Electricity Reliability Corporation (NERC) - NERC's mission is to improve the reliability and security of the bulk power system in North America. To achieve that, NERC develops and enforces reliability standards; monitors the bulk power system; assesses future adequacy; audits owners, operators, and users for preparedness; and educates and trains industry personnel.

National Energy Board (NEB) – This is an independent Canadian federal agency that regulates several aspects of Canada's energy industry. Its purpose is to promote safety and security, environmental protection, and efficient energy infrastructure and markets in the Canadian public interest within the mandate set by Parliament in the regulation of pipelines, energy development and trade.

NIMBY (Not in My Back Yard) – A term used for public opposition to projects within or close to the opponents' community.

Regional Transmission Operator (RTO) – Regional Transmission Organizations were created in the United States as the mechanism by which to achieve wholesale access to transmission in deregulated markets.

Siting – Term used for selecting routing for new transmission and distribution and then securing the required approvals for building in that location.

Smart Meters – Smart meters can measure, maintain and transmit electricity usage data to a utility automatically on a frequency of interest to that utility.

World Energy Outlook (WEO) – The WEO is an analysis prepared by the IEA of the impact of current energy policies, projecting a vision of how energy markets are likely to evolve. An alternative scenario analyzes the potential impact of a number of additional measures to impact energy security and climate change and their costs.

About ClickSoftware

ClickSoftware is the leading provider of mobile workforce management and service optimization solutions that create business value for service operations through higher levels of productivity, customer satisfaction and cost effectiveness. Combining educational, implementation and support services with best practices and its industry-leading solutions, ClickSoftware drives service decision making across all levels of the organization. From proactive customer demand forecasting and capacity planning to real-time decision making, incorporating scheduling, mobility and location-based services, ClickSoftware helps service organizations get the most out of their resources. With over 100 customers across a variety of industries and geographies, and strong partnerships with leading platform and system integration partners - ClickSoftware is uniquely positioned to deliver superb business performance to any organization. The company is headquartered in Burlington, Mass. and Israel, with offices in Europe, and Asia Pacific.

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