IN BRIEF

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The August 2003 Blackout

INTRODUCTION

Just after 4 p.m. EDT on 14 August 2003, the lights went out throughout nearly all of Ontario east of Wawa, in New York State, Ohio, Michigan, northern New Jersey, and parts of Massachusetts, Connecticut, Pennsylvania, Vermont and Quebec.(1) Fifty million people were suddenly left without electricity in one of the most extensive blackouts ever to hit North America.

The event has raised many important questions. What was the chain of events that led to the widespread power outage? How could this happen? Why was such an enormous area affected? What is the role of federal governments in ensuring that it does not happen again? This paper attempts to answer such questions, to the extent that the answers are known to date.

WHAT HAPPENED ON 14 AUGUST?

According to the North American Electric Reliability Council (NERC), at 4:11 p.m. EDT, approximately 61,800 MW(2)of customer load was abruptly lost in the huge regional transmission grid known as the Eastern Interconnection. Power was not restored for up to four days in some areas of the United States, and parts of Ontario experienced rolling blackouts for a week following the initial loss. The blackout also had an economic impact. Canada's gross domestic product fell by 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.(3)

In response to the blackout, the governments of Canada and the United States established a joint U.S.-Canada Power System Outage Task Force to determine the causes of the blackout and make recommendations on how to prevent future outages. Following a thorough investigation, the Task Force submitted a report in April 2004, which described the events of the blackout and their causes, and contained a list of recommendations.

The sequence of events that took place on 14 August is a complex one. Contrary to initial suspicions, the blackout was not sparked by excessive levels of inter-regional power transfers. Transfers were high, but within system limits. Instead, the investigation revealed that a combination of electrical, computer, and human errors was responsible for this unprecedented widespread power outage.

Problems started at 12:15 p.m. EDT, at the Midwest Independent System Operator (MISO) – a reliability coordinator for the bulk electricity supply of a region bordered by Manitoba, Kentucky, Montana, and Pennsylvania. One of MISO's electrical system monitoring tools became ineffective due to inaccurate input data. The next series of relevant events occurred at First Energy (FE), an Ohio control area operator in MISO's region. First, at 1:31 p.m., one of FE's generators tripped and shut down automatically. At 2:14 p.m. a logging system and alarm in the control room failed, hindering FE's ability to monitor its power system. Next, at 3:05 p.m., some of FE's transmission lines tripped as a result of contacting overgrown trees in the right-of-way.

FE, MISO, and neighbouring utilities did not recognize that the entire FE system was in jeopardy until 3:46 p.m. If they had, manually dropping 1,500 MW of electric load around Cleveland and Akron at this point in the sequence of events might have prevented the blackout. After 3:46 p.m., some of FE's key 345-kV electric transmission lines tripped, causing their underlying network of 138-kV lines to fail. Consequently, a major 345-kV line in Northern Ohio was lost, transferring major and unsustainable electrical load burdens to lines in adjacent areas. The uncontrollable blackout cascade spread quickly, as overloaded lines and generators tripped automatically to avoid physical damage to the system. The cascade was finally contained by 4:13 p.m., by which time more

than 508 generating units at 265 power plants had been shut down.

A combination of factors stopped the blackout from cascading further, including: an eventual dampening of the current swings that were causing lines to trip; a high density of higher-voltage line networks that were better able to absorb voltage and current swings and create a barrier; and the fact that some areas, namely the Maritimes and most of New England, became isolated due to line trips. These areas were able to continue to import power from unaffected parts of the grid.

THE GRID

To answer many of the questions raised by the blackout, it is important first to have a basic understanding of what the North America grid is and how it is structured. In North America, most electricity is produced at large, centralized power plants and is delivered to consumers over a network of high-voltage transmission lines, substations and local distribution lines. Over the years, as the production and consumption of electricity have grown rapidly, this network has also grown and become increasingly interconnected. Today, virtually all utilities in Canada and the United States (along with a few in Mexico) are part of one or another of the huge regional transmission grids that now cross interprovincial and international borders. For example, the majority of northeastern provinces and states, including Ontario, New York and Michigan, are part of what is known as the Eastern Interconnection.

The interconnection of individual utility grids offers several advantages. Of particular importance is that it provides some stability to the system in an emergency by allowing a utility that is temporarily unable, for whatever reason, to meet the demands of its customers, to access its neighbour's production until lost generation can be restored, or the demand reduced. Grid interconnection also allows utilities to sell power to each other on a regular basis, making maximum use of generation facilities and thereby reducing overall generating costs.[4]

Interconnection is clearly beneficial in many circumstances. For example, had the Ontario grid been an island unto itself, the province would have suffered several blackouts in the last few years as a result of insufficient generation within the province. Only by importing power from surrounding jurisdictions such as Michigan, New York and Quebec has Ontario been able to meet demand. Yet, as the events of 14 August clearly showed, interconnection also has its dark side. Most notably, it makes utilities, market operators and customers vulnerable to problems that occur outside of their own area. This has led many to question the way in which the electricity grid in North America is structured and managed.

WHO IS IN CHARGE?

It is not as easy as one might expect to answer the question of who is in charge of the North American transmission grid, because no single entity has responsibility for and authority over the entire system. Even before the 14 August blackout, experts were expressing concern that widespread restructuring of the electricity sector in recent years was putting grid system reliability at risk. Regulatory changes both in the United States and, to a lesser extent, in Canada have seen integrated utilities "unbundled" so that different corporate entities are responsible for generation, for transmission and for distribution. The generation part of the equation was freed from strict government control, with generators being allowed to compete in open wholesale markets. Open market access and growing demand provided an incentive to build more power generation facilities. In contrast, the transmission and distribution of electricity remained highly regulated; and over the years, the government-set rates of return offered to owners of transmission lines have been insufficient to attract investment into the construction of high-voltage transmission lines. Consequently, North America was left with a situation in which increasing volumes of electricity were being carried over an antiquated system of transmission lines, stretching them to their technical limits and leaving very little margin for dealing with unforeseen crises.[5]

A result of restructuring and increased interconnectedness is that monitoring and control of the grid are too decentralized to effectively ensure reliability. The mandates, responsibilities and geographical boundaries of utilities and system operators are not always well coordinated, and there have long been fears that gaps in coverage and/or miscommunication could leave some important parts of the system vulnerable, as dramatically illustrated by the events of 14 August.

Moreover, the growth of the electric transmission system in terms of volume of traffic and interstate, interprovincial and international connections has not been matched by corresponding changes to the institutional arrangements for ensuring the reliability of the system. This gap was, in fact, recognized by U.S. authorities nearly 40 years ago following a major blackout in 1965. At that time, the head of the Federal Power Commission said:

> … enormous development of interstate power networks in the last thirty years requires the reevaluation of governmental responsibilities for continuity of the service supplied by them, since it is impossible for a single state effectively to regulate the service from an interstate pool or grid.[6]

At present, the organization with the broadest mandate related to the transmission grid is NERC, a voluntary, non-profit corporation established following the 1965 blackout. NERC's mission is "to ensure that the bulk electric system in North America is reliable, adequate and secure." [7] Its membership consists of 10 Regional Reliability Councils, whose members, in turn, account for virtually all of the electricity supplied and used in all of Canada and the United States, as well as parts of Baja California, Mexico. Members of the Councils include representatives of all sectors of the electric industry, including state, municipal, provincial and investor-owned utilities, federal agencies, rural electric cooperatives, independent power producers, power marketers and consumers. NERC depends entirely on voluntary compliance with its reliability standards and on appropriate, timely communication between the multitude of entities involved in the production, transmission, distribution and dispatch of electricity to ensure system reliability. It has no authority to enforce compliance – a fact that is seen increasingly as a major drawback. NERC officials have stated:

> The changes taking place in the electric industry are altering traditional mechanisms, incentives and responsibilities to the point that our *voluntary* system of compliance with reliability standards is no longer adequate.[8]

NERC is a leading supporter of the development of a new system of mandatory, enforceable reliability standards to address these concerns. Since the August blackout, the Canadian and American governments are also moving towards supporting mandatory reliability standards. For instance, the U.S.-Canada Power System Outage Task Force's April 2004 report states that: "First and foremost, compliance with reliability rules must be made mandatory with substantial penalties for non-compliance."[9]

Many see in such a proposition a natural role for federal authorities. Currently, U.S. and Canadian federal authorities have little to no jurisdiction over the high-voltage transmission facilities owned by utilities that form the backbone of the transmission grid. This is something that many, including the chairman of the U.S. Federal Energy Regulatory Commission (FERC), would like to see change.[10] Both the U.S. Energy Secretary and the FERC chairman have recently suggested that FERC should be given power to enforce as-yet-to-be-developed federal reliability standards for the grid. In fact, reliability provisions are currently included in both the U.S. House of Representatives and Senate versions of pending energy legislation. If they become law, FERC could well empower NERC to act as the agent for implementing the new regulations. Canadian utilities would, as members of NERC, then be bound to meet the same standards.

CURRENT ROLE OF THE CANADIAN AND U.S. FEDERAL GOVERNMENTS

Given constitutional differences, the Canadian federal government is considerably less involved in the monitoring and regulation of electricity markets than is the U.S. federal government. Current federal involvement in both countries is described below.

In the United States, FERC, an independent federal agency, regulates the transmission and wholesale sales of electricity in interstate commerce, under the authority of the *Federal Power Act*. Acting as an economic regulator, FERC takes measures to ensure that the wholesale market for electricity is competitive, that the rules are fair and prices transparent, and that price signals exist for additional investments in grid improvement and expansion.[11] FERC has influence on the Canadian side of the border as well, since many Canadian utilities, such as Ontario Power Generation, are active in U.S. wholesale markets. In order to be allowed to sell electricity at market rates in these markets, Canadian utilities must demonstrate to FERC that, amongst other things, they would not be in a position to unduly influence prices.

In Canada, federal involvement in electricity-related issues is more limited than in the United States. Under the *National Energy Board Act*, the National Energy Board (NEB), an independent federal agency, must issue permits before utilities can undertake the construction of international or interprovincial power lines. NEB approval is also required for exports of electricity to the United States. The federal government is not involved in monitoring or regulating wholesale markets. In essence, responsibility for electricity rests mainly with the provinces. In Ontario, where the blackout affected millions of customers, the market has recently been restructured and opened to competition. The Independent Electricity Market Operator (IMO), a not-for-profit Crown corporation, operates the wholesale market and schedules the movement of electricity across the transmission system. The Ontario Energy Board (OEB) licenses all participants in

Ontario's competitive wholesale market, including the IMO. The OEB regulates transmission and distribution rates, reviews IMO market rules, examines proposed mergers and acquisitions, and reports to the Ontario Energy Minister on the competitiveness, efficiency, fairness and transparency of the electricity market.(12) While the structure of electricity markets differs from province to province, all provinces are ultimately responsible for the rules governing energy within their jurisdiction. System reliability is a function of those rules and of the utilities' participation in NERC, including adherence to NERC reliability standards.

As in the United States, the Canadian federal government has not been involved in the issue of system reliability. In the future, however, because Canadian electricity markets are now so closely integrated with those in the United States, it seems inevitable that the federal government, which has jurisdiction over international trade and energy security, will be increasingly called upon to play a more direct role in overseeing system reliability in this country.

WHAT IS BEING DONE TO PREVENT A RECURRENCE?

In addition to describing the events and causes of the blackout, the U.S.-Canada Power System Outage Task Force submitted 46 specific, technical recommendations aimed at preventing a repeat of the problem. The recommendations, which are in various stages of consideration and/or implementation by governments in both countries, are grouped into four categories: (1) Institutional Issues Related to Reliability; (2) Support and Strengthen NERC's Actions of February 10, 2004; (3) Physical and Cyber Security of North American Bulk Power Systems; and (4) Canadian Nuclear Power Sector. In the Task Force's own view, the first category contains "the single most important" recommendation, and that is that the U.S. Congress immediately enact legislation to make reliability standards mandatory and enforceable. This has been discussed but not yet acted upon in the U.S. Congress. It is further recommended that the Canadian federal and provincial governments work together, and with their U.S. counterparts, to put identical reliability standards in place in this country. The second category encourages U.S. entities to support and continue the reforms that NERC has already begun to put in place. The category on physical and cyber security acknowledges the enormous impact that disruption of large sections of the North American grid can have on the physical and economic well being of Canadians and Americans. Among the most significant recommendations is the call for the designation of a clear authority structure for ensuring physical and cyber security. It is also recommended that the scope of existing bilateral risk management studies be expanded. These studies focus on the "vulnerabilities of shared electricity infrastructure and cross-border interdependencies." The final category on the Canadian nuclear power sector was included at Canada's insistence. It contains only two recommendations. One calls for training of nuclear power reactor operators so that they can isolate the reactors from the sort of cascade event that occurred without having to place the reactors in full shutdown mode. Restarting nuclear reactors after a full shutdown takes much longer than restarting other generating facilities. The second recommendation calls for the Canadian Nuclear Safety Commission to buy and install a back-up generating system for its Emergency Operations Centre, so that it can function fully during a blackout.

CONCLUSION

The electricity sector in North America today is interstate, interprovincial and, indeed, international in scope. It is clearly in the national interest of both the United States and Canada that the electricity grid be secure and reliable. Consequently, one would expect federal authorities in both countries to act on the recommendations of the U.S.-Canada Power System Outage Task Force, and most notably re-evaluate their roles in ensuring the reliability of the grid.

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(1) See the Web site of the North American Electric Reliability Council, http://www.nerc.com/, accessed on 11 September 2003.

(2) One MW, or megawatt, is equal to one million watts (W).

(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*, April 2004, p. 1.

(4) Natural Resources Canada, "Backgrounder: Electricity in Canada," http://www.nrcan-rncan.gc.ca/media/newsreleases/2003/200360b_e.htm, accessed on 4 September 2003.

(5) N. Banderjee and D. Firestone, "New Kind of Electricity Market Strains Old Wires Beyond Limits," *New York Times*, 24 August 2003.

(6) Federal Power Commission, *Northeast Power Failure: A Report to the President by the Federal Power Commission*, 6 December 1965, as quoted by Pat Wood III, Chairman, Federal Energy Regulatory Commission, before the Subcommittee on Oversight of Government

Management, the Federal Work Force, and the District of Columbia, Committee on Governmental Affairs, U.S. Senate, 10 September 2003.

(7) See the NERC Web site, http://www.nerc.com/about/, accessed on 8 September 2003.

(8) *Ibid*.

(9) U.S.-Canada Power System Outage Task Force (2004), p. ii.

(10) *Ibid.*; see also "Bring me your powerless masses," *The Economist*, 21 August 2003.

(11) See the FERC Web site, http://www.ferc.gov/.

(12) See the OEB Web site, http://www.oeb.gov.on.ca/.