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Energy Security Policy Shift of North America and Ontario, Canada Following 2003 Power Blackout: A Review

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Muhammad Adil Khattak[1,*], Tuan Mohamad Hakimi Tuan Yahya[1], Muhammad Wazif Mohd Sallehhudin[1], Muhammad Izzuan Mohd Ghazali[1], Nur Awal Abdullah[1], Nur Athirah Nordin[1], Nur Ainida Mohd Mohsein Dzakurnain[1]

[1] Department of Nuclear Engineering, Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia

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ABSTRACT

Massive power blackout on 14 August 20003 experience in North America and Ontario, Canada became a wake-up call to energy policy maker for energy security in the future. The blackout has brought quite an impact to the public, economic, communication, healthcare and power generation. The blackout estimated to affect 50 million people with 61,800 megawatts electric loss. The loss of electrical supply also causing public insecurity due to fear of 11 September tragedy to repeat again. There also few lesson can be learned from the incident involving the policy for energy security, technology development and maintenance. Thus, this paper will give a review on the 2003 blackout event and the chronology of the incident, the impact and lesson learned from the incident.

Keywords:
Energy security, 2003 power blackout, electrical reliability, North America, Canada

1. Introduction

August 14, 2003, a massive electric power blackout was experience in various parts of the Midwest and Northeast of United States and also Ontario, Canada (Figure 1 and 2). An estimated of 50 million populations and 61,800 megawatts (MW) of electric load in the states of Ohio, Pennsylvania, Michigan, Vermont, New York, Connecticut, Massachusetts, New Jersey and the Canadian province of Ontario have been affected. This was the second most widespread blackout in world history, after the 1999 Southern Brazil blackout [1-12].

The blackout which commenced a few minutes after 16:00 Eastern Daylight Time, resulted in up to 4 days of the power unable to be restored in some parts of the United States. Meanwhile, Ontario suffered rolling blackouts for staggering more than a week before full power was finally restored. United States bore a total loss ranging between \$4 billion and \$10 billion (U.S. dollars) [2,6,7, 10,11,13,14]. In Canada, gross domestic product (GDP) dropped 0.7% in August, resulted in a net loss of 18.9 million work hours, and manufacturing shipments were plunged \$2.3 billion (Canadian dollars) [5,15- 18].

[*] *E-mail address: mr_kohatian@hotmail.com*

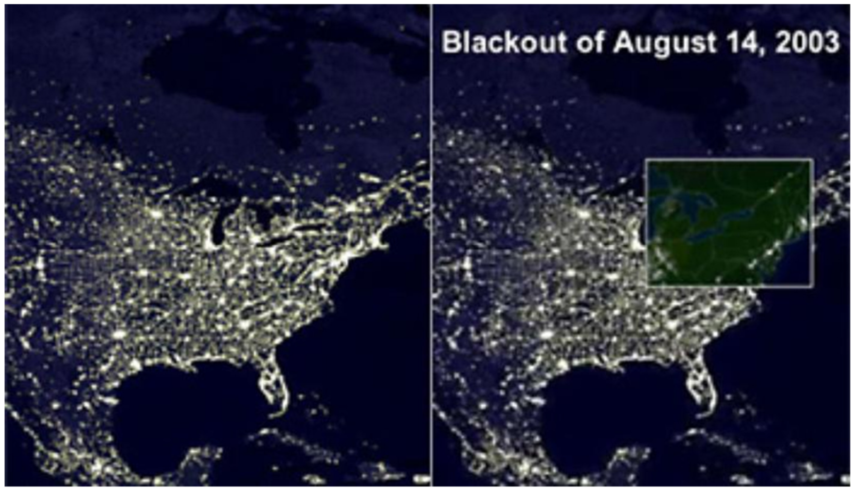

Fig. 1. August 14, 2003, a massive electric power blackout was experience in various parts of the Midwest and Northeast of United States and also Ontario, Canada

Fig. 2. Power outage hit areas marked as red dots

Both the governments of Canada and the U.S. later agreed to form a joint federal task force which aimed to oversee the investigation and directly report to Washington and Ottawa. The task force was led by the Minister of Canada Natural Resource, Herb Dhaliwal and the U.S. Secretary of Energy, Spencer Abraham. Apart from identifying and determining the initial cause of the blackout, the incident investigation also included a thorough examination of the failure of safeguards which was designed to hinder the repetition of the Northeast blackout of 1965. A joint Canada-U.S. council, the North American Electric Reliability Corporation was responsible for dealing with these issues [5,7,13-21]. This review paper aimed to at the substantial information and lessons to be applied and adopted in order to improve and enhance the future electrical reliability and energy security in North America, and the world.

2. Incident

On August 14, 2003, a major power outage has affected the Mid-west and Northeast United States and also involved the eastern Canada [15]. In this report, it is mainly focus to provide a general understanding of how the blackout happens. It is obviously does not include each and every details of the root causes of the blackout as it needs thousands of records of data which need further analysis [12]. However, this report includes thorough investigation done by the joint team form both United States and Canada regarding the 2003 blackout.

An apparent "voltage collapse" is one of the characteristics of the August 14 blackout incident which happens on the transmission system surrounding and also within the eastern Michigan load centres and northern Ohio. In order to transfer electric power from the generation stations to the load centres, transmission system voltage is required. The transmission system voltage is somewhat having the similar functioning with the water main pressure [17].


The time is short, but not too late! GIVE TO THE UNITED APPEAL

WEATHER

THE TELEGRAM

EDITION

Power Failure: What It Could Have Meant

BLACKOUT PROBE BY CANADA. U.S.

Fig. 3. Canada and the U.S. agreed to form a joint federal task force

Reactive power may not travel through long distances as it meets considerable resistance over the transmission lines [22]. Thus, it needs to be close to the point of the demand which includes near the load centres. During the limited reactive supply, a voltage drop along the line might have happened after the increased loading. At that particular point, the transmission system may not transfer electric power to energy users in load centres. In the event of the blackout, most of it appeared to have occurred based on the stated events and the period is from about noon EDR until 4:13 p.m. EDT [7].

12:05:44 – 1:31:34 PM – Generator trips [23]

1) 12:05:44 – Conesville Unit 5 (rating 375 MW)
2) 1:14:04 – Greenwood Unit 1 (rating 785 MW)
3) 1:31:34 – Eastlake Unit 5 (rating: 597 MW)

The first plant situated in Conesville, Ohio is reported to be tripped at 12:05:44 and also the Greenwood Unit 1 plant which is in north of the Detroit area is reported to be tripped at 1:14:04. However, the Greenwood Unit 1 came back to service at 1:57:00. The Eastlake Unit 5 which is in northern Ohio along the southern shore of Lake Erie is connected to 345 kV transmission system and tripped causing the electric power flow pattern to change over the transmission system [24].

2:02:00 PM – Transmission line disconnects in Southwestern Ohio

4) Stuart – Atlanta 345 kV

The line disconnected from the system due to a brush fire under a portion of line. Some hot gasses form a fire ionized into the air and caused the air to conduct electricity thus short-cut the conductors [23].

3:05:41 – 3:41:33 PM – Transmission lines disconnect between eastern Ohio and northern Ohio

5) 3:05:41 – Harding-Chamberlain 345 kV
6) 3:32:03 – Hanna-Juniper 345 kV
7) 3:41:33 – Star-South Canton 345 kV

The reason for the Harding-Chamberlain line going out of service is unknown. The Hanna Juniper line however, contacted a tree and created a short-circuit to ground which caused the line to disconnect itself. The Star-South Canton line also had disconnected and reclosed twice earlier in the day. However, the significance of those events is not yet clear [25].

3:45:33 – 4:08:58 PM – Remaining transmission lines disconnect from eastern into northern Ohio [25]

8) 3:45:33 – Canton Central-Tidd 345 kV
9) 4:06:03 – Sammis-Star 345 kV

The Canton Central-Tidd disconnected at 3:45:33 and reconnected 58 seconds later but not the transformer which does not reconnect and thus isolated the 138 kV system from the 345 kV support. The Sammis-Star 345 kV line then disconnected at exactly 4:06:03, which completely blocked the 345 kV path into northern Ohio from eastern Ohio [25].

4:08:58 – 4:10:27 PM – Transmission lines into north-western Ohio disconnect, and generation trips in central Michigan

10) 4:08:58 – Galion-Ohio Central-Muskingum 345 kV
11) 4:09:06 – East Lima-Fostoria Central 345 kV
12) 4:09:23-4:10:27 – Kinder Morgan (rating: 500 MW; loaded to 200 MW)

The Galion-Ohio Central-Muskingum and East Lima-Fostoria Central transmission lines disconnected and blocked the transmission paths from southern and western Ohio into northern Ohio and eastern Michigan [25].

4:10:00 – 4:10:38 PM – Transmission lines across Michigan and northern Ohio disconnected, in northern Michigan and northern Ohio generation trips off line, and northern Ohio separates from Pennsylvania

13) 4:10 – Harding-Fox 345 kV
14) 4:10:04 – 4:10:45 – Twenty generators along Lake Erie in northern Ohio (loaded to 2174 MW total)
15) 4:10:37 – West-East Michigan 345 kV
16) 4:10:38 – Midland Cogeneration Venture (loaded to 1265 MW)
17) 4:10:38 – Transmission system separates northwest of Detroit
18) 4:10:38 – Perry-Ashtabula-Erie West 345 kV

Along Lake Erie during the period 4:10:04 – 4:10:45, twenty generators (loaded to 2174 MW) tripped off line [25]. The power flows into the northern Ohio and eastern Michigan load centers on the remaining paths was increased with the loss of the generation. Also includes the west-east transmission lines that cross Michigan.

4:10:40 – 4:10:44 PM – Four transmission lines between Pennsylvania and New York is disconnected

19) 4:10:40 – Homer City-Watercure Roa d 345 kV
20) 4:10:40 – Homer City-Stolle Road 345 kV
21) 4:10:41 – South Ripley-Dunkirk 230 kV
22) 4:10:44 – East Towanda-Hillside 230 kV

The northern part of the Eastern Interconnection remained connected to the rest of the Interconnection at only two locations which are the west through the 230 kV transmission line between Ontario, Manitoba, and Minnesota and the east through the ties between New York and New Jersey [10].

4:10:41 PM – Generation trips and transmission line disconnects in northern Ohio

23) Fostoria Central-Galion 345 kV
24) Perry 1 nuclear unit (rated 1252 MW)
25) Avon Lake 9 unit (rated 616 MW)
26) Beaver-Davis Besse 345 kV

Part of the pathway from central to northern Ohio is formed by the Fostoria Central-Galion line. That path was already blocked by the East Lima-Fostoria Central line
disconnecting at 4:09:06 and the combination of the Galion-Muskingum-Ohio Central line disconnecting at 4:08:58. Perry 1 nuclear unit and Avon Lake 9 tripped off line virtually simultaneously [8–13].

4:10:42 – 4:10:45 PM – Transmission paths in northern Ontario and New Jersey disconnect, the northeast portion of the Eastern Interconnection isolated

27) 4:10:42 – Campbell unit 3 (rated 820 MW) trips
28) 4:10:43 – Keith-Waterman 230 kV
29) 4:10:45 – Wawa-Marathon 230 kV
30) 4:10:45 – Branchburg-Ramapo 500 kV

Eastern Michigan at 4:10:43 was still connected to Ontario. However, the Keith-Waterman 230 kV line was disconnected. The Ontario system separated when the Wawa-Marathon 230 kV line disconnected along the northern shore of Lake Superior at 4:10:45 [10].

4:10:46 – 4:10:55 PM – New York splits east-to-west. New England (except southwestern Connecticut) and the Maritimes separate from New York and remain intact.

31) 4:10:46– 4:10:55 – New York-New England transmission lines disconnect

New York and New England disconnected at this time. Most of the New England area became an island with generation and demand [10]. However, southwestern Connecticut was separated from New England and remained tied to the New York system for about one minute.

32) 4:10:48 – New York transmission east-west splitted.

4:10:50 – 4:11:57 PM – Ontario separates from New York west of Niagara Falls and west of St. Lawrence. Southwestern Connecticut separates from New York and blacks out.

33) 4:10:50– The Ontario system just west of Niagara Falls and west of St. Lawrence separates from New York.
34) 4:11:22 – Long Mountain – Plum Tree 345 kV

35) 4:11:57 – Transmission lines remaining between Ontario and eastern Michigan separates

4:13 PM – Sequence of the cascade essentially complete [26]

3. Impact

The massive blackout on 14 August 2003 covering the Northeast United State and Ontario, Canada estimated to affected 50 million people. The blackout began few minutes after 4:00 pm in the state of Ohio, Michigan, Pennsylvania, New York, Vermont, Massachusetts, Connecticut, New Jersey, and Canadian province which later recovered around 10:00 pm [15,27,28]. This blackout had brought various of impact to the US and Canada. The blackout in the middle of the day forcing people at work to leave their work and cause power station shutdown (nuclear power plant), economic disruption, healthcare effect, internet communication disconnection, transportation problem and public insecurity [11,15,27-30].

No electricity gives quite an impact to the people to move from one point to another point. The blackout impact in the midday felt more deeply to the people in Ney York City where a large population of people still at work. The street become clogged with traffic lights out and no electricity to operate the subway [29]. The flight also being cancelled in three major metropolitan area airports. The airliners in the air also being rerouted to the terminal beyond blackout [30].

Next, the absent of electricity also causes the cell tower to stop operating which causing communication using cell phone become useless. Although, internet communication was generally unaffected, but the thousands of corporate and other institutional network that depend on internet to operate affected greatly [31]. The affected communication also could lead to action of authorities towards emergency situation be delayed. Electricity blackout also causing public insecurity. The public are fearing that the tragedy of 11 September would repeat. They also in fear of terrorist attack due to the blackout. Security system also failed without electricity which could increase the possibility of crime rates [29].

Nuclear power plant also among the impact from the electricity blackout as it required electric to operate. In order to ensure safety of facilities as well as public safety from radiation, the nuclear power plant need to be shut down in the absent of electricity. During the blackout, nine nuclear power plant in US and seven nuclear power plant in Canada experienced rapid shutdown [15]. The trip resulted from the plant response to the grid disturbance which actuate the protective feature of the plant for safe shutdown. Loss of offsite power supply brought concern whether emergency system could remove the decay heat even though the control has been inserted. Apart from power production is disrupted, the safety of public from radiation release in case of accident also become a concern.

During the blackout, mortality for accidental and non-accidental increased. The blackout put the hospital on its emergency power generator which complicate the management of illness. Power operated home medical equipment such as ventilators and oxygen conservers also cannot be used [32]. With failure of cellular phone service, the ambulance respond become slower and the hospital emergency room also overcrowded with people seeking for electricity on medical equipment. Apart from that, there also a possibility of vaccine spoilage due to loss of refrigerator [1].

As for the economic view, there was a catastrophic shock faced after the disaster. The ICF consulting calculated roughly that the August 2003 disaster has cost around $7 billion to $10 billion dollar [2]. The total approximation were based on the direct cost per kWh of the power outage, mostly from the lost production, food spoilage losses and the wages for overtime works [33]. The total loss also cause by the indirect cost which mainly were from the secondary effects of the direct cost such as the cost to maintain the spoiled food. In a different studies, Ohio Manufacturers'

Association (OMA) stated that it was estimated that the direct cost from the disaster was roughly around $1.08 billion for 12,300 manufacturing companies which speaks for about 55% of total manufacturing company in the state [34]. It was calculated that each of the company averagely loss for nearly $88,000 with average shutdown duration for about 36 hours due to the blackout. The collaboration of the Detroit Regional Chamber with the University of Michigan's Institute of Labor and Industrial Relations analyse that the Detroit Region financial loss for almost $220 million in total due to that blackout [35].

In conclusion, electricity supplies via the national grid network in every country around the world have been an important role in daily activities. In today's modern societies, the absence of the electricity will bring many collateral effects towards the society since they have started to be dependent on the technologies that uses electricity such as keeping low body temperature with air conditioning, communication through gadgets, freezing food with freezers. Thus, the electricity supply became dependency by the society for their comfort, communication, healthcare, food supply, security and transport [36]. In any event of absence in the electricity such as national electricity blackout, these societies will be heavily affected as such that their basic needs were taken away.

As for the blackout event that occurred in the Northeast United State and Ontario, Canada, the 50 million people in the region faced multiple issue regarding various factor such as the insecurity, loss of communication, patient healthcare, traffic for transportation, handling power plants especially nuclear power plants and economic interruption. All of these factor has occurred for only 6 hours but it is also cost approximately $10 billion to the affected region [37]. The main sector affected was the industrial sector which depend mostly on electricity. After the accident occurred, the affected region and other countries have taken a counter measure in order to prevent this catastrophic event from occurring in the future.

4. Lesson Learned

From this major blackout event, a number of lesson could be learned to prevent the same incident from taking places in the near future.

4.1 A Comprehensive and Integrated Policy Response

One of the biggest problem in this incident, is the inability to act fast by the governing body to prevent the event from inflicting heavy collateral damage to the public. The late response time has bring detrimental effect to both social security and the safety of the public which may bring them closer to the risk [38]. Thus to overcome this problems, a new real time, comprehensive, integrated policy reform should be taking place in the energy industry in order to be successfully address the issues. An improvement not only needed to be focus on the technical but also towards the many polices dimensions that involve legal, regulatory, structural arrangements, operating practices, technical standards, coordination exchange of information, asset management and also the vegetation management. To further integrate the whole spectrum of values between business and policies, even all the key stakeholders that possesses share in the electrical transmission system needed to be taken account also in reforming the system security towards greater heights [39]. The stakeholder in this sense are related to the government, system operators, regulators, owners and even the market participants itself. Every parties involve are needed to hold some degree of liability in this issue so that a solid reform framework that are multidimensional and multi-oriented could be fully developed and generated. Especially the government which hold the biggest liability of all should provide adequate training programme to each related personnel and to also promote leadership values among the key player to effectively coordinated and implement the new approach. Even so, this type of framework adjustment would not only bring goodness but some form of conservative management platform whereby strict rule and regulation might affect the overall economic cost of constructing and managing the power transmission system.

4.2 Investing in The Technology

Another important major milestones that needed to be address in this issues is investment in both the people and the technology [38]. Both element possesses adequate quality and values that provide enough impetus to reform the energy distribution transmission framework policies. For the later one, continuous development in technological aspect has helped improve energy transmission system security in both security and efficiency aspect. The development of the technology could further facilitate improvement in terms of accuracy, quality and the development of a more dynamic system modelling that could be projected to be highly compatible with the real-life scenario. Such modelling provides greater landscape of contingency scenario-plan framework that could be exploited and analyses for the purpose to promote greater conservative safety philosophy and along the way, ruled out the highest possibility of the accident scenario. At the same time, the development of a more sensitive modelling technique, should allow greater mode of contingency plan in which the dynamic of the event can be understood in a more fundamental and specific manner. Moreover, technological development may also improve the effective control of the operator towards the transmission system that could provide better real-time response during the operational period in order to prevent congestion by systematically managing the uncertaints situation for the purpose to fully utilize the service time system restoration protocol. From the general perspective, technological development has the potential to assist in the real time coordination control of the electrical transmission system and a more holistic management of system security that spanning a large sum of multidimensional variables. Increasing flexibility and security should be the main values to bring forward the future identity of the integrated system technology [39]. Moreover, improvement in flexibility aspect will provide powerful resilience of the transmission system from any other form of hazardous and to analyse the event deeply which enable better innovation techniques solutions that could improve the whole landscape of reliability, power quality and even the market domain itself. Any form of regulatory body or institution that provide barricade for the development for the more effective technological solution should be removed entirely from the energy market. To do so, the government should play an effective role by providing enough financial assistance and encourage strong cooperation between government-private institutions in the energy sector.

4.3 Investing in the People

Evens so, all of the technological development will never succeed unless there exist a balance of improvement between the former and the human control factor. Thus, only highly trained personnel should be allowed to operator the transmission system. The operator itself should have adequate set of skills to mitigate and manage any form of uncertain event of the dynamic real time environment. They also need to have sufficient knowledge and academic background to interpret and analyse the dynamic event that taking places by providing any form of mitigation plan or to utilize any form of technology available for the former purpose. Even though, typically each personnel had already undergone the emergency simulation training by the governing body nevertheless, a new set of training programmes should be implemented in their training module framework that involve the real-time analysis event. Such effort will have the tendency to improve the operator skills of manipulating and controlling the dynamic real time operating challenges. The convergence factor in this issue is to produce a talented personnel that are not just have the knowledge to operate but also knowledge to make adequate decision when they needed it the most [39]. A fully integrated joint training programme between the government bodies and the private company should be taking place more frequently to facilitate the training programme coordination and the development of skilful personnel in handling the newly integrated transmission technology. To implement a more conservative framework, the training programme also should be invested heavily beyond the operator personnel that involves other areas of relevant professional such as the personnel that involve in managing the information flow of the technology system and even the technical engineering staff that support and secure the system operation [38]. Investment in this particular direction, will not only improve the transmission system safety but also, provide a safe track record of information management regarding the transmission system that would improve the transmission system security and reliability.

4.4 Asset Performance and Maintenance

With respect to the Ontario blackout event that struck the heart of the Canadian and American energy security framework, it is reported that one of the cause of the event is the presence of the computer bug that inhibit the signal transmission system for reaching the related operator personnel [38] This may have cause the operator to be unaware of the real situation that really take places in every geological landscape that connected through the same electrical distribution system. Even so fundamentally, the transmission system security could be classified as one of the technology that are dependent and predictable in some degrees thus, a reliable assets performance monitoring programme should be implemented and strongly support to increase the reliability of each system component involve. For example, the condition based monitoring programme should be utilize to the full extent to target any major component that are on the brink of low degree reliability. This particular approach will surely optimize the maintenance efforts due to its ability to reduce the time and cost spending on detecting each and every defect available on each component. Moreover, the approach will improve the effort to minimize the spreading of risk towards the component failure event at a least minimum amount of cost. The monitoring - maintenance approach can provide a fully integrated coordination of maintenance cycles across the connected region of the integrated transmission system thus, increasing the system security level to the new height. At the same time, even the standard review plan for the effective verification and enforcement of each component should be reconsider again as to improve the effectiveness of those approach [39]. Maintenance requirement and the performance standards should be reviewed also in the greatest respect for the purpose solely in providing an appropriate balance between the reliability of the system operation and the equipment protection value. Moreover, strict regulation control should never be the main highlighted element that will reduce the efficiencies of the asset management rather, an adequate regulatory influence should be enough to monitor and preserve the integrity of the major component. The regulatory body needed to understand that each and every decision they made will have a big impact on the maintenance policy of the company thus, it is favourable if the institution itself to allow adequate recovery for the maintenance purposes.

5. Conclusion

50 million of people only know they had lost electricity when the lights went out on 14 August 2003, not that a tightly knit system had been ripped apart all the way from Detroit to Toronto to New York City. Electric control centres people even confused with the tragedy. The magnitude of the problem was spread out through Midwest which showed a black-out Times Square because the news was out on CNN. The citizens also frightened and thought that this could be terrorist conspiracy. Blackout tragedy which still being questioned until today had not been completely investigated because no one has known the truth behind this happened. Only assumption has been concluded from this accident which is because of cyber-attack towards the operator emergency monitoring system computer.

There are many actions need to be performed in order to prevent the same event happened in the future. Comprehensive and integrated policies as the solid reform framework to protect the country's safety from any danger. Technological development aspect also need to take into account as one of the step to improve the energy transmission system security including trained personnel to operate the transmission system. Strict regulations control should take as priority to monitor and control the system operation which applied not only to government but also to all regulatory body.
The paper gives a description on the subject, of the main events that lead to the blackout in US and Ontario, Canada. It describes also the chronology of the event, the impact of the blackout on public and the lesson learned from the accident. As a result, the analysis of the incident suggests some conclusions on the practices of the system operators in the operation of interconnected systems. A higher level of coordination should be ensured due to the higher and higher level of manipulation of the transmission resources and of uncertainties subsequent to the electricity market. Besides, conclusions on the technical requirements of protection systems are provided.

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