CA-IR-6

Ref: T-3, Pages 9 to 14.

Regarding the outages cited and the lessons learned from each, how many of the outages would Mr. Pollock consider "avoidable" had proper maintenance (i.e., tree trimming) and engineering (i.e., proper protective relay calculation and setting) been performed? Provide copies of all documentation and/or analysis to support the response.

HECO Response:

As referenced in Mr. Pollock's testimony, the summary descriptions and lessons learned for the various outage events cited were drawn from the reports referenced in his testimony. For the outages cited, the documents referenced in Mr. Pollock's testimony are as follows:

Reference 1 - Consortium of Electric Reliability Technology Solutions Grid of the Future, White Paper on Review of Recent Reliability Issues and System Events, Prepared for the Transmission Reliability Program, Office of Power Technologies, Assistant Secretary for Energy Efficiency and Renewable Energy, USDOE, Prepared by John F Hauler, Jeff E. Dagle, Pacific Northwest National Laboratory, August 30, 1999.

- November 9-10, 1965 – Northeast Blackout
- July 13-14, 1977 – New York City Blackout
- December 14, 1994 – Western States Cascading Outage
- August 10, 1996 – Western States Outage.

Reference 2 - Interim Report: Causes of the August 14th Blackout in the United States and Canada. US-Canada Power system Outage Task Force, November 2003.

- August 14, 2003 – Northeast/Midwest US Blackout

Reference 3 - Stone & Webster Management Consultants report, Hawaiian Electric Company, Investigation of July 13, 1983 Blackout, February 1984.

- July 13, 1983 Oahu System Blackout

These document are voluminous and are available at HECO's Regulatory Affairs office. Please contact George Hirose at 543-4787 to make arrangements for a review.

Additional information about the outages and an assessment of whether an outage was "avoidable" is outlined below.

<u>November 9-10, 1965 – Northeast Blackout (Reference 1):</u>

Additional Information from Reference 1 (page 10): "The tripping was caused by backup relays that, unknown to the system operators, were set at thresholds below the unusually high but still safe line loadings of recent months. These loadings reflected higher than normal imports of power from the United States into Canada, to cover emergency outages of the nearby Lakeview plant. Separation from the Toronto load produced a "back surge" of power into the New York transmission system, causing transient instabilities and tripping of equipment throughout the northeast electrical system."

Assessment: In 1965, utilities were learning about interconnecting with one another and at that time the interaction of interconnected systems was not as well known as it is today. In this instance, the utility did not know the relay settings were inadequate for line loading under certain contingency situations, and a trip occurred when a new operating scenario was encountered. Had that specific scenario been studied and appropriate settings implemented, the outage would likely have been avoided. However, at that point in time there was much less experience operating interconnected systems and the power system analysis tools available for analyzing complex networks were more primitive than available today. A single contingency analysis that today takes minutes, could take days to setup and run with the tools available at that time. The increasing complexity of the electrical system contributed to the cause of this outage. This major event was the primary impetus for creation of the NERC.

<u>July 13-14, 1977 – New York City Blackout (Reference 1)</u>

Additional Information from Reference 1 (page 10-11 & 19-20): "A lightning stroke initiated a line trip which, through a complex sequence of events, led to total voltage collapse and blackout..." "Several aspects of this event were exceptional for that time. One of these was the very slow progression of the voltage collapse. Another was the considerable damage to equipment during re-energization. This is one of the "benchmark" events from which the electricity industry has drawing many lessons useful to the progressive interconnection of large power systems."

Assessment: Studies of large systems can be complex and time consuming. The operation of large systems is also a very complex undertaking. In this instance, stronger interconnections with neighboring systems may have prevented the voltage collapse. Had the system been studied for this type of scenario, appropriate transmission ties constructed, and operating practices adjusted the outage may have been avoided.

December 14, 1994 – Western States Cascading Outage (Reference 1)

Assessment: Three events combined to initiate this large outage as noted in Mr. Pollock's testimony.

- Insulator contamination resulted in a proper trip of the first line
- A relay erroneously tripped a parallel line
- Bus geometry at Borah Substation forced the trip of another line from the Jim Bridger Plant

A contaminated insulator initiated the sequence of events. Cleaning of the insulators (either through maintenance or adequate rainfall) would have prevented the first trip, however, that relay did operate properly. The second event was due to an error in the relay setting. The bus geometry at Borah contributed to the third event by forcing the trip of the third line. Had the relay that tripped for the second event been set properly, the second trip wouldn't have occurred and the outage would have likely been avoided.

Please consult Reference 1 if additional information is desired.

August 10, 1996 – Western States Outage (Reference 1)

Additional Information from Reference 1 (page 14): "Temperatures and loads were somewhat higher than on July 2. Northwest water supplies were still abundant – unusual for August – and the import from Canada had increased to about 2300MW. The environmental mandates curtailing generation on the lower Columbia River were still in effect. Over the course of several hours, arcs to trees progressively tripped a number of 500kV lines near Portland, and further weakened voltage support in the lower Columbia River area. This weakening was compounded by a maintenance outage of the transformer that connects a static VAR compensator in Portland to the main 500kV grid." "One unusual aspect of this event was that the Northeast-Southeast Separation Scheme, for controlled islanding under emergency conditions, had been removed from service"

Assessment: There were a number of planned maintenance outages or generation curtailments in effect at the time, and so all parts of the system were not in service when the first of the initiating events occurred. The initiating event was arcs to trees. Had the trees been trimmed, the outage would have likely been avoided. In the context of Mr. Pollock's testimony with regard to the Development and Application of Transmission Planning Criteria, the fact that not all parts of the system were in service at the time the outage began is important to note, and underscores the importance of conducting studies and planning the system to allow for maintenance outages of transmission system components.

August 14, 2003 – Northeast/Midwest US Blackout (Reference 2)

Additional Information from Reference 2 (page 23): "The Causes of the Blackout – The initiation of the August 14, 2003, blackout was caused by deficiencies in specific practices, equipment and human decisions that coincided that afternoon. There were three groups of causes:

Group 1: Inadequate situational awareness at FirstEnergy Corporation (FE)
Group 2: FE failed to manage adequately tree growth in its transmission rights-of-way
Group 3: Failure of the interconnected grids reliability organizations to provide effective diagnostic support."

The reader is referred to the referenced report for added detail if desired.

Assessment: This outage could have been avoided had proper steps taken to mitigate the deficiencies identified prior to the outage.

July 13, 1983 Oahu System Blackout (Reference 3)

Assessment: All parts of the system were not operational at the time of the outage, as two major 138kV lines were out of service for repairs. A three phase fault occurred on the Kahe-CEIP 138kV line and then relays mis-operated to trip three additional 138kV lines leading to the system blackout. The relay mis-operation contributed to the blackout, and had the relays operated properly the outage may have been avoided. However, it must be noted that at the time the 138kV system was vulnerable because two 138kV lines were out of service for maintenance. If all 138kV lines had been in service at the time of the event, "the blackout would not have occurred" (Reference 3 , page 131). In the context of Mr. Pollock's testimony with regard to the Development and Application of Planning Criteria, key recommendations from the Stone and Webster report (Reference 3) are summarized in Mr. Pollock's testimony, and underscore the need to plan and construct the system to withstand multiple contingency outage scenarios. These key recommendations include:

- The need to consider additional 138kV lines to strengthen the system to withstand multiple contingency outages;
- Planning should include consideration for minimizing the impacts of "maximum credible outages", which are multiple contingencies that have a low probability of occurrence;
- Addressing the reliability issue of an outage to the two lines serving Pukele on a common right of way;
- Addressing the inability to have one transmission line out of service for an extended period of time.

Please consult Reference 3 if additional information is desired.

In a perfect world, all events other than the uncontrollable actions of nature would be theoretically avoidable. The lessons learned from operating electric utility systems have taught the industry that power systems must be constructed and operated in a manner that allows for equipment failures and mis-operation, due to both nature and other causes, while still providing reliable service. One of the lessons learned from studying past transmission system outage events is that multiple contingency events do occur, and should be addressed in planning studies and operating practices. The industry has made adjustments to transmission system planning criteria, operating practices, maintenance practices, and incorporated new technology, to remove and/or mitigate identified problems and avoid outages in the future. It should be noted that implementation of new technology carries some risk because while the technology may improve operations in one area, the technology may also introduce new and unknown issues that haven't been observed in the past. These unknown issues can result in an outage before they are identified. It should also be recognized that as systems evolve, becoming larger and more complex, new issues will arise. These issues, which may potentially result in outages, will need to be identified, studied, and appropriate actions taken to minimize or eliminate their impact. While 100% reliability is not attainable, each utility should learn from industry wide outage event studies and strive to identify and implement appropriate changes to planning and operating practices to avoid similar events on their local system.