Public Version

First Annual Report
Verification of
Commonwealth Edison's
Commitments Related to the
Downers Grove Substation Fire

presented to:

Staff of the
Illinois Commerce Commission

by:

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Confidential information deleted from this report.

I. Introduction

The Illinois Commerce Commission (ICC or Commission) retained The Liberty Consulting Group (Liberty) to investigate the root causes and implications of an August 10, 2005, fire at Commonwealth Edison's (ComEd's) Downers Grove substation. Liberty's December 16, 2005, report contained eight conclusions and six recommendations. ComEd made a presentation to the ICC Staff on December 19, 2005, and submitted written responses to Liberty's recommendations on February 3, 2006. ComEd also made a presentation to the ICC on March 7, 2006. The ICC then retained Liberty to verify ComEd's compliance with its plan to implement Liberty's recommendations.

Liberty submitted data and interview requests to ComEd, and spent three weeks on site in October 2006, two weeks on site in February 2007, and three weeks on site in July/August 2007. This first annual report gives the status of Liberty's verification to date. Overall, Liberty found that ComEd was on schedule on the installation of fire protection enhancements at substations. Liberty did not find any instances in which ComEd failed to meet its commitments. ComEd did not complete one action item on time.

Liberty organized ComEd's commitments to the ICC in 37 action items based primarily on the company's February 3, 2006, response document. The following sections of this report describe each item and Liberty's verification work on each. The table immediately below provides the summary status of each action item.

#	Report	Item	Did ComEd meet its commitments and take actions as reported?	Is Liberty's verification work complete?	Date of Liberty's completion
1	II.B.1	Critiques of Downers Grove RCI	Yes	Yes	October 2006
2	II.B.2	Comparison with Pharmaceutical Company	Yes	Yes	October 2006
3	II.B.3	Self-Assessments	Yes	No	
4	II.B.4	Root Cause Analysis Training	Yes	Yes	October 2006
5	II.B.5	Benchmarking	Yes	Yes	February 2007
6	III.B.1	Distribution Joint Construction Training Programs	Yes	Yes	August 2007
7	III.B.2	Field Bulletin on Distribution Cable Joints	Yes	Yes	October 2006
8	III.B.3	Hydraulic Press Calibration	Yes	Yes	October 2006
9	III.B.4	Tracking Cable Space Joint Installations	Yes	Yes	October 2006

#	Report	Item	Did ComEd meet its commitments and take actions as reported?	Is Liberty's verification work complete?	Date of Liberty's completion
10	III.B.5	Engineering Approval of Cable Space Joint Installation	Yes	Yes	October 2006
11	III.B.6	Transmission Underground Quality Control Requirements	Yes	Yes	October 2006
12	III.B.7	Transmission Joint Training Benchmarking	Yes	Yes	August 2007
13	III.B.8	Transmission Joint Smoothness Specification	Yes	Yes	October 2006
14	III.B.9	Transmission Joint Construction Benchmarking	Yes	Yes	October 2006
15	IV.B.1	Responsibilities of the Operations Systems Engineer	Yes	Yes	February 2007
16	IV.B.2	Review Existing Reports for Adequacy	Yes	Yes	October 2006
17	IV.B.3	Analysis of Operating Cables Above Normal Ratings	Yes	No	
18	V.B.1	ComEd's Substation Fire Protection Plan		No	
19	V.B.2	Substation Prioritization	Yes	Yes	October 2006
20	V.B.3	Substation Inspections	Yes	Yes	October 2006
21	V.B.4	Thermographic Inspections		No	
22	VI.B.1	Substation Fire Response Procedure Training	Yes	Yes	August 2007
23	VI.B.2	Division of Authority between the OCC and the TSO	Yes	Yes	October 2006
24	VI.B.3	CSR Fire Response Procedure Improvement	No*	Yes	February 2007
25	VI.B.4	Substation Fire Drills	Yes	No	

#	Report	Item	Did ComEd meet its commitments and take actions as reported?	Is Liberty's verification work complete?	Date of Liberty's completion
26	VI.B.5	Fire Alarm Recognition and Priority Improvement	Yes	Yes	October 2006
27	VI.B.6	Site Fire Plan Creation		No	
28	VI.B.7	Operation of Circuit Switchers and Circuit Breakers	Yes	Yes	February 2007
29	VII.B.1	Single-Transformer Distribution Substations	Yes	Yes	February 2007
30	VII.B.2	Multiple-Transformer Substations – Transfer Capability	Yes	Yes	February 2007
31	VII.B.3	Multiple-Transformer Substations – Categories	Yes	Yes	February 2007
32	VII.B.4	At-Risk Distribution Customers	Yes	Yes	February 2007
33	VII.B.5	Feeders without Direct Ties to Other Substations	Yes	Yes	February 2007
34	VII.B.6	Distribution Substation Restoration Options and Tools	Yes	No	
35	VII.B.7	Communication of Distribution Substation Risk Assessment	Yes	Yes	August 2007
36	VII.B.8	Transmission Substation Categories	Yes	Yes	February 2007
37	VII.B.9	Transmission Substation Restoration Guide	Yes	Yes	February 2007

* # 24: ComEd met the commitments but did not meet its commitment date for reinforcing proper communications.

Even though Liberty has completed its verification work on many individual items, important verification work remains. ComEd's installation of important fire protection enhancements at substations will continue for the next couple of years. Liberty will also inspect substations with these improvements and observe or evaluate substation fire drills. Liberty will monitor ComEd's

resolution of related substation issues such as battery capacity and standpipe grounding. Other significant matters that will be included in future verification work include the review of root cause investigation reports, ComEd's equipment and plans for distribution substation restoration, and the guidelines for operation of cables above normal operation.

II. Root Cause Analysis

A. Recommendation

Liberty recommended that ComEd assess its own root cause analysis methods and consider obtaining formal root cause training. More in-depth analyses would help ComEd determine the most effective changes it could make to cure underlying problems. In its determination of these changes, ComEd should not make its recommended actions contingent upon verifying that such action is consistent with common utility practice.

B. ComEd's Response and Liberty's Verification

ComEd agreed with the recommendation and indicated that it would take several actions to continue to improve its root cause process.

1. Critiques of Downers Grove RCI

ComEd said that it requested the Exelon Nuclear staff, which has experience with the root cause investigation (RCI) process, to review the Downer's Grove RCI report. ComEd committed to having its Performance Assessment staff review the critiques from Liberty and Exelon Nuclear of the Downers Grove RCI in order to strengthen its RCI process. ComEd indicated that this action would be complete by April 1, 2006.[1]

ComEd received feedback from Exelon Nuclear's root-cause analysis expert on January 12, 2006, and provided a summary of the feedback it received.[2] This feedback noted some weaknesses in the Downers Grove RCI report. ComEd also said that all of its Performance Assessment Group (PAG) coordinators met in March to discuss the critiques of the Downers Grove report. ComEd provided a summary of the PAG meetings.[3] Exelon Energy Delivery (EED) issued a revised RCI procedure on March 31, 2006.[4]

Liberty reviewed EED's procedure and RCI report template. These documents provide sound guidance for future root-cause analyses. Liberty also reviewed documentation related to the Exelon Nuclear feedback and the PAG coordinator meetings. Therefore, Liberty considers this commitment verified and closed.

2. Comparison with Pharmaceutical Company

ComEd committed to comparing its root-cause process with a pharmaceutical company located in the area by March 1, 2006. ComEd said that it would review the observations and incorporate

[1] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[2] Response to Data Request #463.
[3] Response to Data Request #464.
[4] Response to Data Request #402.

identified improvements to strengthen the ComEd corrective action and root cause analyses programs.[5]

Liberty reviewed a report from a ComEd trip to a pharmaceutical company in Illinois. The visit occurred on December 23, 2005. Liberty also reviewed two changes that ComEd made to its Corrective Action Program resulting from the trip.[6] Liberty considers this commitment verified and closed.

3. Self-Assessments

ComEd committed to completing by March 1, 2007, two self-assessments of root-cause investigations. The assessments were to verify organizational compliance to the governing RCI requirements and to include items such as a review of the scope of the RCI and a review of the effectiveness of key corrective actions.[7]

In its December 16, 2005, report on the Downers Grove substation fire, Liberty was critical of ComEd's root cause investigation. Moreover, Liberty found that in reports on four substation fires, ComEd did not address important, underlying issues that, if identified and acted on, could have prevented or limited the consequences of subsequent events. ComEd provided four RCI reports for Liberty's review that it completed after issuance of Liberty's report. These were:[8]

- TSS 35 Lakeview Fire RCI, May 4, 2006
- , May 5, 2006
- , September 14, 2006
- TDC 574 Bartlett Outage, January 19, 2007.

Liberty defined a root cause as one of the underlying events, conditions, or factors that created or allowed the undesired outcome. A root cause should be specific, something over which management has control, and something for which the analysts can generate effective recommendations.

In the first (Lakeview) of the above four reports, ComEd determined that the root cause was not having adequate standards for burning oil containment at certain substations. This root cause statement meets the root cause definition. In addition, the report's corrective actions (recommendations) should be effective in preventing similar incidents.

ComEd did not make the same quality of concise root cause statements in the two root causes identified in the second (May 5, 2006) of the above four reports. However, the report did identify underlying, specific factors that were at the root of the incident. These included management's enforcement of, and the lack of clarity in, procedures. The report's corrective actions, if performed thoroughly, should be effective.

[5] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[6] Response to Data Request #401.
[7] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[8] Responses to Data Requests #465 and #482.

In Liberty's opinion, however, the third and fourth RCI reports did not contain real root cause findings. In the third (September 14, 2006) report, . Neither statement meets what Liberty believes is the correct root cause definition. . The report does not address many fundamental aspects of the incident. .

The Bartlett report (the last of the four listed above) did not contain what Liberty views as an adequate statement of root cause(s). The report indicated that the first root cause was the type of contact configuration used in a motor-operated disconnect. The fundamental reason for the outdated contact configuration being present is not clear, especially because ComEd identified similar locations on its system in 2003. The second was a statement of ComEd's practice of "run-to-failure" of secondary transformer leads. While this statement identified something that was underlying, specific, and under management control, it did not lead to effective corrective actions without a determination that the practice was wrong.

One of the issues identified in the Downers Grove study was the failure of operators at the OCC[9] to recognize and acknowledge the fire alarm. The same thing occurred during the Bartlett event, despite the corrective measures implemented after the Downers Grove incident (because dispatchers defeated those measures). A primary finding in Liberty's review of Downers Grove was ComEd's failure to implement lessons learned from earlier events. It is noteworthy that ComEd's RCI report for the Bartlett event did not mention the repetition of similar conditions from Downers Grove.

ComEd provided reports on two self-assessments of RCI reports to show that it met its commitment.[10] These were assessments on:

- TSS 35 Lakeview Fire RCI, May 4, 2006
- , September 14, 2006.

The assessments verified organizational compliance to the governing RCI requirements, included a review of the scope of the RCI, and evaluated the effectiveness of key corrective actions. Therefore, ComEd met the exact wording of its commitment.

ComEd's RCI of the Lakeview substation fire was a very good root cause analysis. However, with regard to the September 14, 2006 RCI, ComEd's assessment dismissed an observation with one of the two root cause statements as argument over rhetoric. The self-assessment found that effectiveness of corrective actions was "indeterminate." This means that either not enough time had elapsed to determine the effectiveness or the documentation of the actions taken was poor. A

[9] OCC is the Operations Control Center.
[10] Response to Data Request #482.

more disciplined and thorough root cause analysis may have resulted in recommendations (corrective actions) that would have been more effective.

Liberty concluded that while ComEd met its commitment, the overall root cause analysis process has not reached a satisfactory level of maturity. The first two RCI reports produced by ComEd after the Downers Grove fire were well prepared. However, in Liberty's opinion, the last two were not. They did not identify root causes, did not address obvious questions, and did not address whether the incident reflected on previous lessons that ComEd should have learned. Liberty will keep this item open and will continue to review certain ComEd RCI reports.

4. Root Cause Analysis Training

ComEd indicated that it subscribes to the [redacted] system for training related to root cause analyses and problem investigation.[11]

Liberty verified ComEd's use of the [redacted] system and reviewed some of the manuals and newsletters provided to ComEd.[12] A preferred requirement for the lead position on a ComEd RCI team is attendance at a two- or five-day [redacted] training course.[13] Liberty considers this commitment verified and closed.

5. Benchmarking

ComEd reported that it consults with other companies and experts within and outside of the electric utility industry to draw upon their knowledge base to improve its programs and standards, or bring greater value to its customers by becoming more efficient. ComEd said that it does not use benchmarking as a justification for adopting the least rigorous standard.[14]

Liberty knows that ComEd frequently uses benchmarking and consultation with other companies. Related to the issues arising from the Downers Grove fire, and as examples, ComEd sought information from others on transmission joint construction training and underground construction specifications.[15]

However, the reason Liberty mentioned benchmarking in its Downers Grove substation fire report related to ComEd's RCI report, not whether ComEd appropriately used industry information. The RCI report made its recommendations conditional on comparable industry benchmarking.[16] Liberty said that ComEd should not make its recommended actions contingent upon verifying that such actions are consistent with common utility practice.[17]

[11] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[12] Response to Data Request #302.
[13] EA-ED-1003, response to Data Request #402.
[14] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[15] Responses to Data Requests Nos. 401, 415, and 417.
[16] Response to Data Request #128.
[17] Liberty Report on the Investigation of the Downers Grove Substation Fire, December 16, 2005, p.83.

Liberty verified that ComEd's RCI reports issued after the one for Downers Grove did not contain the conditional statements on its recommended corrective actions.[18] With ComEd's renewed focus on its RCI efforts, Liberty does not view this matter as a continuing problem. Therefore, Liberty considers this commitment verified and closed.

[18] Response to Data Request #465.

III. Cable Splicer Training and Quality Control

A. Recommendation

Liberty recommended that ComEd study, and improve as required, the quality of the training, instructions, and supervision given to personnel who perform critical operations like installing cable connections. A properly installed joint should not be the weak link in a cable system. However, ComEd has experienced several instances in which poor workmanship or the failure to recognize an unsatisfactory connector installation has caused serious problems. ComEd should require certification of personnel who install cable splices. ComEd should keep records of joint construction to augment other means of accountability in the workplace.

B. ComEd's Response and Liberty's Verification

ComEd agreed with the recommendation and indicated that it would take several actions to identify and implement various training, quality control, and inspection improvements relating to underground cables.

1. Distribution Joint Construction Training Programs

ComEd's response indicated that it would review the distribution cable joint construction training and qualification program requirements for adequacy, and modify the program requirements for underground splicers by May 1, 2006. Thereafter, ComEd said it would implement a modified training program to close identified training gaps by December 1, 2007. ComEd planned to use this program for both new and refresher underground splicer training.[19]

Liberty verified that ComEd modified its beginner splicer-training (1st Period) program prior to May 1, 2006. ComEd included or added more detail to the program in the following areas:[20]

- lessons-learned and critical steps in joint construction, information from the Field Bulletin prepared in January 2006
- prefabricated joint kits
- differences between XLPE and EPR cables
- installing and inspecting completed connectors
- damaged and failed joints and terminations
- electrical tracking
- problems that cause improper joints
- electric stress in cables
- photographs and information from the Downers Grove substation fire
- the cost of connector failures in terms of dollars and reliability
- proper compression of connectors
- construction standards for making splices and terminating with kits

[19] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[20] Response to Data Request #408, and interview with EED Training, November 10, 2006.

- quality control requirements in Exelon's "Event Free Performance Tool Book."

ComEd said that it has used the enhanced, 1st Period program since March 2006. ComEd also said that it modified its refresher splicer training program, and will modify the advanced-training (2nd Period) program with the new information added to the beginner program. Refresher student training includes the review of joint construction specifications and methods. The first refresher course began in September 2006.[21]

In October 2006, Liberty verified ComEd's initial improvements to the 1st Period program. Liberty found that the improvements should enhance the quality of cable splices. In August 2007, Liberty reviewed ComEd's implementation of the modified training programs for both advanced and refresher underground splicer training.

ComEd conducts 1st Period splicer training for those qualified for the training, but who have not had cable-splicing training. Second Period training is for those who have had 1st Period training plus nine months of experience with a qualified splicer. Third Period training is for those who have had 1st and 2nd Period training and 18 months of experience with a qualified splicer. ComEd provides annual refresher training to fully qualified splicers. The topics in the annual refresher training vary from year to year. Liberty reviewed ComEd's revised 2nd Period and 3rd Period training manuals. Liberty verified that the manuals included the additional content to the 1st Period training materials, including critical aspects of cable joint and termination construction, electrical stress theory, lessons learned and photographs from the Downers Grove Substation cable space fire, and, in general, what not to do when making a cable joint. ComEd conducted 1st Period training in January and April 2007; it conducted 2nd Period training programs during June 2006 and March 2007; it conducted a 3rd Period training program in July 2007. ComEd included the new material in its September 2006 refresher training. Examples included in ComEd's refresher training were failed cables, joints, and terminations.[22]

Liberty found that, before December 1, 2007, ComEd identified and closed gaps in its splicer training programs by including critical joint construction details, electric stress theory, and lessons learned from the Downers Grove Substation fire in all three levels of its splicer trainer programs, and in its refresher program. The inclusion of the new material in all three levels and the refresher course exceeds ComEd's original commitment.

Liberty considers this commitment verified and closed.

2. Field Bulletin on Distribution Cable Joints

ComEd indicated that it issued a Field Bulletin on January 20, 2006, that highlighted several areas of cable preparation and joint installation. ComEd also said that is it had begun communicating the Field Bulletin to construction crews and engineering personnel.[23]

[21] Interview, EED Training, November 10, 2006.
[22] Interview and review of splicer training material, EED Training, July 27, 2006.
[23] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

Liberty verified that ComEd distributed Field Bulletin 06-05 on January 20, 2006, and that the bulletin described critical steps of cable joint construction. The bulletin indicated that a conclusion of ComEd's root cause investigation of the Downers Grove cable space fire was that ComEd should review critical steps in cable joint construction, and provide necessary training. The bulletin included photographs and details about the improperly crimped connector that caused the joint failure at the Downers Grove Substation. It described how and why to place the cable straight within a joint, to square cut conductor ends, to remove insulation and shielding, to prepare conductor surface, to clean interfaces, to use inhibiting compounds, to use crimping dies and hydraulic presses, to center the joint body, and to bond the shields. ComEd issued the bulletin to all construction, engineering, new business, project and contract management, and training field employees.[24]

Liberty considers this commitment verified and closed.

3. Hydraulic Press Calibration

ComEd indicated that it would evaluate and create hydraulic press routine maintenance and calibration requirements by March 15, 2006.[25]

Liberty verified that ComEd created procedures and frequency requirements for calibrating the hydraulic presses used to construct cable joints prior to March 15, 2006.[26] ComEd communicated the new requirements for annual calibration in field bulletins and in a daily system status call. It provided the procedures for the calibration in EED's Construction and Maintenance procedure CM-ED-810008.[27]

Liberty considers this commitment verified and closed.

4. Tracking Cable Space Joint Installations

ComEd's response indicated that by May 1, 2006, it would develop a checklist for cable-space joint installations, and that the checklist would include a method to track who installed the joint. After development of the checklist, ComEd indicated that it would perform periodic QC audits during the installation of cable space joints.[28]

Liberty verified that ComEd completed on April 26, 2006, a draft of its cable-space joint checklist methods document, including the joint construction checklist for field personnel. The draft checklist requires that both the person-in-charge and the supervisor verify that the correct following of all critical steps in joint (both lead and plastic) construction. It also indicates die size used, cable size, number of crimps, hydraulic press calibration date, and when, where, and why the joint was installed in the cable space or basement.[29]

[24] Response to Data Request #406.
[25] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[26] Response to Data Request #407.
[27] CM-ED is simply a designation for Energy Delivery's construction and maintenance procedures.
[28] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[29] Response to Data Request # 409.

ComEd formalized the checklist in CM-CE-P028,[30] which was effective on May 30, 2006. In this document, ComEd revised the draft checklist to include verification that Engineering approved the installation of a plastic joint in a cable space, and to include verification that ComEd had installed fire wrapping on plastic jacketed joints.[31]

ComEd reported that it had not installed any plastic cable joints since requiring use of the checklist. However, it has installed lead joints and provided examples to Liberty of completed checklists of some of these installations.[32]

Although ComEd said that it would be performing "periodic audits" of cable joints in cable spaces, ComEd actually plans to have a supervisor review any cable space joint installation.[33] Liberty concluded that this is an acceptable alternative to the original commitment.

Liberty suggests that ComEd indicate on its joint construction checklists the identification numbers of the hydraulic presses used. This could be valuable in tracking improperly crimped joints if ComEd discovered a calibration problem with a press. Otherwise, Liberty found that the checklist procedure provides appropriate quality control for cable space joint installations.

Liberty considers this commitment verified and closed. ComEd completed this action item on time and the checklist requirement and content comply with ComEd's commitments.

5. Engineering Approval of Cable Space Joint Installation

ComEd said that it would require specific approval from Engineering before it installs a new joint in the cable space of a substation.[34]

Liberty verified that on February 3, 2006, ComEd issued Tech Bulletin TB-05-052 "Cable Joints in Substation Cable Spaces/Basements." This bulletin requires that ComEd cannot install joints (plastic) on concentric neutral cables in substation cable/basement spaces, except with engineering approval. If ComEd does install a plastic joint, it has to be fire-wrapped.[35] In addition to the bulletin, procedure CM-CE-P028, Rev. 0 (mentioned in item #4 immediately above) requires engineering approval.

Liberty considers this commitment verified and closed; ComEd met its commitment that Engineering approval is required to install plastic joints in cable spaces.

[30] CM-CE is a designation for ComEd's construction and maintenance procedures.
[31] Response to Data Request # 409.
[32] Response to Data Request # 409.
[33] Response to Data Request # 410.
[34] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[35] Response to Data Request # 411.

6. Transmission Underground Quality Control Requirements

ComEd said that it implemented quality control (QC) requirements for transmission cable and component construction and installation. Construction specifications contained the QC requirements, which required the use of a checklist and sign off by the splicer and a supervisor for joint and termination construction. ComEd indicated that it would apply the QC requirement to work performed by both ComEd and contractor employees. ComEd also said that it determined the record retention requirements for worker qualification and for tracking who installed which joints.[36]

Liberty verified that ComEd added a quality control checklist to its construction standard C6216, dated December 7, 2005, for normal joints in 138 kV transmission high-pressure, fluid-filled, pipe-type cables in manholes, and added steps in its sleeve-welding standard C5342, dated January 10, 2006, to improve proper sleeve welding.[37]

The joint assembly checklist includes:

- date, joint location, cable type, splicers name, and supervisor's or inspector's name
- critical steps, and QC check verifications
- sign off and approval signatures
- submittal to Transmission Line Engineering and retention for at least 10 years.[38]

Additions to the sleeve assembly standard include:

- clamping joint halves before spot welding
- performing a die-penetrant test on every weld.

ComEd said that it currently uses only one contractor for performing joint welds, and it has provided the contractor with these revised specifications.[39]

Liberty considers this commitment verified and closed. Liberty found that ComEd complied with its response and that the actions should improve quality control of applicable transmission cable sleeves and joints.

7. Transmission Joint Training Benchmarking

ComEd's response indicated that it benchmarked its requirements with other utilities and established criteria for a transmission joint construction training and qualification program. ComEd was to follow this by the development of an associated training program by November 1, 2006.[40]

[36] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[37] Response to Data Request # 413.
[38] Response to Data Request # 414.
[39] Response to Data Request # 413.
[40] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

In October 2006, Liberty verified that ComEd had compared its underground transmission training program with eleven other utilities. Of the eight utilities with equipment similar to ComEd's, only one has an internal program that qualifies employees to perform all transmission cable terminations and joints on its system. The others contract the majority of termination, joint, and repair work to contractors. ComEd has developed a transmission underground training program, TQ-ED-1024, dated November 18, 2005, structured similarly to the one utility. This employee-training program will contain modules for LPFF, HPFF, and XLPE[41] joints and terminations.[42]

In August 2007, Liberty reviewed ComEd's revisions to its transmission underground cable and component construction and installation training programs, which it was to complete by November 1, 2006. Liberty reviewed the transmission underground training program dated October 23, 2006. This revision included sections for LPFF, HPFF, XLPE, and PILC[43] cable joints and terminations. The material included detailed descriptions of the various cables, joints, terminations, specifications, and checklists that installers may use. ComEd organized the program in training modules with key knowledge test questions. ComEd requires trainees to pass written tests and to demonstrate skills by making cable joints for the instructor.

In October 2006, ComEd qualified 14 employees through training conducted by a contractor using the new training program. Those trained included the transmission underground AME[44] and one transmission First Line Supervisor. Transmission underground crew leaders and splicers made up the remaining personnel trained. ComEd said that it plans to conduct this transmission underground training every three years. ComEd reported that its employees are currently qualified to construct PILC and LPFF splices and terminations. ComEd reported that because its employees are not currently qualified to perform HPFF and XLPE splices and terminations, contractors make them. ComEd directs the contractors to use the training material and specifications as a guide and requires the use of checklists. A qualified ComEd transmission underground engineer must inspect and sign off on contractor work.[45]

Liberty found that ComEd formalized and revised its training program for its transmission underground splicers, crew leaders, AMEs, and engineers. It implemented quality control checklists for transmission underground joint and termination construction. ComEd completed modifications to its transmission underground training program by November 1, 2006.

Liberty considers this commitment verified and closed.

[41] LPFF is low pressure, fluid (cable dielectric fluid) filled, HPFF is high-pressure fluid (cable dielectric fluid) filled, and XLPE is cross-linked polyethylene (plastic).
[42] Response to Data Request #415.
[43] PILC is paper-insulated lead cable.
[44] AME is Area Maintenance Engineer.
[45] Interview and review of transmission underground training material, Transmission Service, July 27, 2006.

8. Transmission Joint Smoothness Specification

ComEd said that it would revise transmission joint construction specifications by April 1, 2006, to include a required connector smoothness factor in transmission joints during new construction.[46]

Liberty verified that ComEd, by March 21, 2006, included in the five 138 kV normal and stop joint construction specifications directions for polishing the entire connector such that it is free of burrs, scratches, or projections.[47]

Liberty found that ComEd completed this action item. Liberty considers this commitment verified and closed.

9. Transmission Joint Construction Benchmarking

ComEd said it would review existing transmission underground construction specifications for completeness by benchmarking against cable design companies and other utilities.[48]

Liberty verified that ComEd has had its transmission joint specifications reviewed by its cable joint manufacturer and integrated resulting changes into its specifications by March 24, 2006. ComEd used information from four utilities to help confirm changes made in the specifications regarding preparing connectors.[49]

Changes included:

- using lead plugs to fill indents in connectors rather than compound.
- polishing the entire connector
- requiring a quality control checklist.

Liberty found that ComEd completed this action item. Liberty considers this commitment verified and closed.

[46] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[47] Response to Data Request # 416.
[48] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[49] Response to Data Request # 417.

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IV. Heavily Loaded Feeders

A. Recommendation

Liberty recommended that ComEd develop guidelines for dealing with heavily loaded feeder systems.

To repair a faulted cable, ComEd transferred load to a circuit at the Downers Grove substation. The added load caused the functioning circuit to exceed its normal rating for many hours during the months preceding the Downers Grove substation fire. The heavily loaded circuit contained the joint that failed and started the fire. Liberty concluded that ComEd did not have procedures or guidelines for operations, engineering, and construction related to heavy loading on a feeder over an extended period.

B. ComEd's Response and Liberty's Verification

ComEd agreed with the recommendation and stated that it would take several actions to provide guidance to its operations personnel for dealing with heavily loaded feeders.

1. Responsibilities of the Operations Systems Engineer

ComEd's response said that, by March 1, 2006, it would review and clarify the responsibilities of the Operations Systems Engineer to include:[50]

- Prioritizing repairs based on circuit loading levels and durations above normal loading,
- Monitoring repair status,
- Expediting repairs, and
- Escalating issues when repairs are delayed.

On February 24, 2006, ComEd issued Revision 2 of its existing "Out-of-Configuration Program" (OP-ED-P018),[51] which provides governance and oversight to the operational configuration of ComEd's transmission and distribution system.[52] The new Section 3.3 requires the System Engineer to:

- Assess system readiness through a review of the equipment out of service for maintenance, failed equipment and components, and new requests for outages,
- Work with regional planning and transmission groups to address overloads and long range plans, and to interact with regional planning on contingency plans for circuits and equipment as necessary,
- Prioritize circuit, line, and equipment repairs, and
- Push resolution of out-of-configuration issues and manage system risk due to failures and planned maintenance activities.

[50] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[51] OP-ED designates an operating procedure for Energy Delivery.
[52] Response to Data Request #419.

ComEd again revised OP-ED-P018 (Rev. 3, effective December 30, 2006) to assign ownership and authority to the Vice President-ED Operations. This revision also required operations personnel to prepare work requests and identify failed components and devices.[53]

ComEd completed Action Request (AR) 22407 (Cable Operating Guidelines) on February 28, 2006.[54] This document provided some guidance for operating distribution cables above the summer normal limits. On March 1, 2006, ComEd rolled out its new cable operating guidelines to operations and indicated that it would update OP-ED-P018 or OP-ED-4004 in the future to reflect these guidelines.[55] ComEd incorporated AR 22407 into its Trouble Response Procedure, OP-ED-4004, effective May 31, 2006.[56] ComEd added some clarification to the guidelines between the dates it finished AR 22407 and the effective date of the procedure. OP-ED-4004, Rev. 10, effective January 29, 2007, established that ComEd should assign to overloaded cables that are below the 1-day Emergency limit a priority 10.[57] Liberty discusses the adequacy of these guidelines under verification item #3 below.

ComEd stated that the System Engineer has the authority to raise the work priorities of circuits out of configuration as work and resource allocation proceeds and that this process takes place on a daily basis. Other actions that the System Engineer can take to meet the operating guidelines include developing contingency plans, rolling out generators to reduce overloads, and dropping load under certain conditions.[58]

Liberty concluded that ComEd reviewed and clarified the responsibilities of the Operations Systems Engineer to include the monitoring of repair status, expediting repairs, and escalating issues for delayed repairs by the March 1, 2006, commitment date. With regard to the effective date of the cable operating guidelines, Liberty confirmed that ComEd met its commitment date and immediately rolled out the final guidelines for use by operations.

Liberty considers this commitment verified and closed.

2. Review Existing Reports for Adequacy

ComEd's response indicated that by March 1, 2006, it would review its existing reports, tools, and reporting processes for adequacy and make modifications based on this review. The reports, tools, and processes that it was to review included PI Historian, System Control and Data Acquisition (SCADA), electronic and paper maps, Switching Routine Database, BRIO reports from Passport,[59] the Distribution Load Management Program, and the weekly "out of configuration" (Operations Report 0003 or OPS0003) report.[60]

[53] Response to Data request #419 Supplement.
[54] Response to Data Request #305.
[55] Response to Data Request #422 Supplement.
[56] Response to Data Request #419.
[57] Response to Data Request #419 Supplement. Priority 10 means that the item must be cleared within 24 hours.
[58] Interview of October 10. 2006.
[59] BRIO is the trade name of the software module in Passport that structures reports. Passport is ComEd's work management system.
[60] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

On February 23, 2006, ComEd issued a progress report on its review of its existing reports, tools, and reporting processes for adequacy and making modifications as required. The progress report listed its responsibilities as 100 percent complete.[61]

The report stated that ComEd reviewed various tools and reports with all of its system engineers who can assist in tracking and monitoring system readiness. The major reporting tools reviewed included PI Historian, the new Ranger SCADA system, electronic and paper maps, switching routines, Distribution Load Management Program (DLMP), BRIO reports, weekly out of configuration call with stakeholders, and various OCC databases such as routine number, switch ticket, Switching Request System (SRS), and operating logs.

ComEd's report review found one gap. That gap was in the BRIO OPS0003 report, which tracks circuits out of configuration. ComEd determined that the report only listed items if ComEd was using its own resources and did not capture the item if it used only contractor resources. ComEd closed this gap on February 17, 2006.

ComEd tracks the overload of feeders with its DLMP. ComEd added two new columns to the report to indicate the number of days that the circuit has appeared on the overload report in the last 12 months and the number of consecutive days that the overload occurred.[62] ComEd made this revision to the DLMP on June 20, 2006, having not identified the need for it in the earlier review. The DLMP report also categorizes the overload as a category 1 if it was above the 1-day Emergency limit, category orange-2 if at the 5-day Emergency limit, and category 2 if it is above the Normal rating, but below the 1-day Emergency rating. The category displayed is only that of the current overload.[63]

ComEd stated that it discusses in the daily operations call new circuits added to the circuits out of configuration report or circuits that have had their priorities changed. In addition, ComEd discusses the four oldest circuits on a Tuesday morning executive call.[64]

Liberty considers this commitment verified and closed.

3. Analysis of Operating Cables above Normal Ratings

ComEd said that by March 1, 2006, it would complete its analysis of data collected from other utilities and research organizations such as the Electric Power Research Institute (EPRI) and National Electric Energy Testing Research & Applications Center) (NEETRAC) regarding industry practices for operating 12kV cables between normal and emergency loading levels. ComEd would then revise its operating guides to include guidance for operation of these cables as practical.[65]

[61] Response to Data Request #420.
[62] Response to Data Request #420.
[63] Interview of October 10, 2006.
[64] Interview of October 10, 2006.
[65] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

During January 2006, ComEd contacted representatives from four manufacturers of cables and members of the Insulated Cable Engineers Association (ICEA) who are the owners of the ICEA cable standards.

Also during January 2006, ComEd contacted engineers from five electric utilities regarding this same matter. All of these utilities said they use ICEA standards and Association of Edison Illuminating Companies (AEIC) guidelines for their cable ratings under normal and emergency conditions. The utilities surveyed apply a duration to the emergency temperature limits, but do not keep track of the accumulated duration over the life of the cable.[66]

Based on the above data inquiries, ComEd concluded that there was no defined industry practice for operating cables between their normal and emergency limits. Therefore, ComEd created its own cable operating guidelines on February 28, 2006.[67]

As of May 31, 2006, ComEd's cable operating guidelines provided the following:[68]

- If a component's daily peak load is at or below the Normal rating, no load relief is required. The repair/replacement of a main stem component that is driving an abnormal configuration will be prioritized as a priority 20 as specified in EED Procedure WM-ED-14.[69]
- If a component is operating above its Normal rating,[70] action will be taken to reduce the components daily peak load below its Normal rating if system conditions permit. Normal ratings should not be exceeded during scheduled switching unless required by system constraints. Work will be prioritized based on the magnitude of the overload. The document does not provide guidance related to the specific action time period requirements.

[66] Response to Data Request #421.
[67] Response to Data Request #421.
[68] Trouble Reporting Procedure OP-ED-4004, response to Data Request #419.
[69] EED is Exelon Energy Delivery. WM-ED is a work management document in Energy Delivery.
[70] In the interview of October 10, 2006, ComEd stated that it interprets this loading description as "above normal, but below the 1 day emergency rating."

- If a component has been operating at its 5-day Emergency limit (90 percent of 1-day Emergency limit)[71] for 4 consecutive days (96 hours), then operations has an additional 24 hours to take action and reduce the load. Furthermore, in order to reset the 5-day Emergency rating, the circuit's peak loading must return to its Normal limit for 120 hours. ComEd does not provide specific guidance for loadings that are above the 5-day Emergency limit but below the 1-day Emergency limit and no specific guidance is given as to what load level must be achieved in the 24-hour action period.
- If a component is operating above its 1-day Emergency limit, immediate action must be taken to reduce the loading below that limit.

[redacted].

ComEd stated that its philosophy in rating its cables covered by these standards was to keep the conductor temperature at or below 130°C, thus assuring cable operation in a temperature range that will not cause deterioration and ultimate failure. [redacted]. ComEd also stated that in the calculation of their 24-hour (1-day) rating and their 120-hour (5-day) rating, it assumed no load cycles, a full duct bank, and the hottest cable in the duct bank already at a 90° C temperature. ComEd calculated its 5-day/1-day emergency cable ampacity limits as the ampacity that would cause the cable to reach emergency temperatures at the end of the 5-day/1-day period. The emergency temperature for various extruded cable is 130° C and it is 110° C for PILC cable. System studies have shown that the 5-day rating is between 91 percent and 95 percent of the 1-day rating.[72] ComEd uses a factor of 90 percent for a cable's 5-day rating as a percentage of its 1-day rating.[73] ComEd believes that this approach adds additional conservatism to its cable rating methods.

ComEd stated that it constructed its Equipment Overload Guidelines that appears as Attachment 3 to procedure OP-ED-4004 (Trouble Response Procedure) in a building block manner. For example, if a contingency occurred that placed equipment components above their 1-day emergency ratings, the operator would take immediate action to bring the loadings below that value. The amount of load relief obtained would determine the operators' next action. If actions brought loading down below normal limits, no further action would be required. If loadings were still above Normal ratings, then the actions would be dependent on how far the loading level was above the Normal rating.

ComEd completed the Cable Operating Guidelines on February 28, 2006.[74] This document provided some guidance for operating distribution cables above the summer normal limits. On

[71] In the interview of October 10, 2006, ComEd stated that it interprets this loading description as "above the 5-day rating, but below the 1 day emergency rating."
[72] Response to Data Request #469.
[73] Response to Data Request #469.
[74] Response to Data Request #305 Supplement.

March 1, 2006, ComEd rolled out its new cable operating guidelines to operations and indicated that it would update OP-ED-P018 or OP-ED-4004 in the future to reflect these guidelines.[75]

Liberty concluded that this commitment is verified, but Liberty will keep this item open until the apparent inconsistencies noted by Liberty between the actual operating practices and design philosophy are reconciled.

Although ComEd met its commitments and met them within the specified timeframe, Liberty is concerned that ComEd's application of its cable operating guidelines is inconsistent with the assumptions used in the development of cable ratings. If ComEd is to interpret its guidelines such that when a cable is operating above its Normal rating that it is also below its 1-day rating, then operator action time to reduce cable loading below its Normal rating should be 24 hours or less. Liberty also believes that if ComEd is to interpret its guidelines such that when a cable is operating at its 5-day rating that the cable is operating above its 5-day rating, but below its 1-day rating, that the cable should only be allowed to do so for a maximum of 24 hours and that the loading must be reduced below normal loading limits within that time period. Even the case cited by ComEd when the cable is at its 5-day rating for 4 days does not specify the requirement that loading must be reduced at or below normal limits in the stated 24-hour action time period. Liberty suggested that ComEd review and revise its cable loading guidelines as applicable to be consistent with the assumptions used in their development.

In July 2007, ComEd provided a copy of its Trouble Response Procedure – OP-ED-4004 – Rev. 13, which ComEd scheduled to become effective on July 30, 2007, pending additional internal review and comment. The procedure included Attachment OP-ED-4004-3, Line Overload Guidelines, which ComEd was revising to reconcile the inconsistencies noted above.[76]

In making this revision, ComEd introduced a new cable rating called the "Mid-Emergency Rating Limit." This new limit is the lesser of the 5-day Emergency limit or the arithmetic average of the Normal and 1-day Emergency limit. If a cable has been operating above its normal limit on a peak load basis, but below its Mid-Emergency Rating Limit for 9 consecutive days (216 hours), then operations has an additional 24 hours to take action and reduce the daily peak load to below the Normal limit. Furthermore, in order to reset the Mid-Emergency Rating Limit, the circuit's peak loading must return to its Normal limit or below for 120 hours.[77]

ComEd's Normal, 1-day, and 5-day Emergency ratings are already in the Ranger SCADA system and cause an alarm when exceeded. Those ratings are also in the Distribution Load Management Program (DLMP). The ratings for the new Mid-Emergency ratings are only located in DLMP.[78] ComEd states that it is evaluating putting the new Mid-Emergency rating into the Ranger system. The dispatchers use the System Engineers (first shift for the 5-day week) or the shift managers to obtain the Mid-Emergency rating value. Liberty suggests that it is better to

[75] Response to Data Request #422 Supplement.
[76] Response to Data Request #483.
[77] Response to Data Request #483.
[78] Response to Data Request #483.

have all ratings in Ranger, so as to not disrupt the dispatcher's thoughts and actions when system conditions require prompt decision-making.[79]

Liberty's review of ComEd's revision resulted in additional questions and concerns. These related to the applicability of supporting calculations, prioritizing overloaded cables by percent overload, and cable temperature creep over weekends. Although ComEd met its commitments and took the actions reported for this item, Liberty leaves this item open for additional evaluation.

[79] Interview of August 7, 2007.

V. Substation Vulnerability to Fires

A. Recommendation

Liberty recommended that ComEd continue to inspect, evaluate, and implement changes at substations with vulnerabilities to fires like those that have occurred in the past. It should evaluate substations that are similar in design to Downers Grove to determine which have the potential to result in long duration outages to a large number of customers. It should implement the lessons learned from the Downers Grove and other earlier fires in a manner that mitigates this potential loss of service to customers. It should continue and complete as soon as practical its infrared inspections of joints in cable spaces. It should develop a formal method for prioritizing cable-space fire-protection enhancements to reduce the outage risks caused by cable space fires. It should determine the timeliness and cost-effectiveness of various options to reduce quickly the most vulnerable substations.

B. ComEd's Response and Liberty's Verification

ComEd agreed with the recommendation and said it would take several actions to develop and implement improvements at substations to reduce the risk of customer and equipment outages caused by fires.

1. ComEd's Substation Fire Protection Plan

ComEd's response indicated that its newly formed fire-protection engineering group developed a substation fire-protection plan for 2006 and 2007, and that the design and fieldwork for this plan was underway. This plan specifies additional fire protection improvements for approximately 120 of ComEd's substations.[80] These improvements include items such as:

- Wrapping of concentric neutral cable joints and adjacent cables
- Installation of floor penetration seals
- Installation of fire detection systems
- Installation of fire suppression systems
- Relocation of identified substation battery main feeds from the cable space to the first floor for substations similar to Downers Grove.

Liberty verified that by January 4, 2006, ComEd developed a comprehensive multi-year substation fire-prevention plan for 350 substations and several tunnels. Since the date of the response, ComEd determined that 130 substations[81] out of the 350 substations have similar risk of fire as the Downers Grove substation. It plans to complete fire prevention actions on these substations, by priority, for 45 substations by the end on 2007, 67 substations by the end of 2008, and the remaining by the end of 2010.[82]

[80] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[81] Response to Data Request # 425.
[82] Response to Data Request # 461.

Liberty verified that engineering and fieldwork under this plan is underway.[83] Liberty also verified that the plans[84] included the action items indicated in the response as follows:

- Wrapping of concentric neutral cable joints and adjacent cables.
- Installation of floor penetration seals.
- Installation of fire detection systems.
- Installation of fire suppression systems.
- Relocation of battery leads.
- Develop site fire pre-plans.[85]

The table below shows ComEd's status of implementing these fire protection measures as of July 27, 2007.[86]

Project	Total Planned	Total Complete	Last Year of Planned Installation
Cable Wrap	141	82	2008
Penetration Seal	140	117	2008
Fire Detection	38	34	2009
Fire Suppression	119	8	2014
Battery Leads	64	36	2009
Site Pre-Plans	353	104	2010

As of August 2007, Liberty inspected the fire prevention work completed at seven substations. In all cases, Liberty found all penetrations sealed, battery-related leads relocated from the cable space to the main floor, cable joints and nearby cables wrapped, fire shields installed under control cable pans, exposed control cables near power cable wrapped, fire-proofing installed on cable space hatch doors, and site fire pre-plans in place. Liberty also reviewed a site fire plan for one of the substations similar to Downers Grove Substation. Site fire pre-plans, kept in locked boxes near substation entry gates, provide fire emergency information to fire fighters and first responders. The materials in the site fire pre-plans include:[87]

- emergency phone numbers
- explanation of hazards
- firefighter general guidelines
- equipment explanations and photographs
- electrical one-line diagrams
- certain MSDS sheets

Liberty observed that at one substation ComEd had installed a water standpipe for fire fighter usage connected to the fire suppression system in the substation, approximately 30 feet outside of the substation boundary fence and outside the protection of the substation grounding grid.

[83] Response to Data Request 424; and Interview, Fire Protection Engineering Manager, of October 12, 2006.
[84] Response to Data Request # 425.
[85] These are sometimes called "pre-plans" to prevent confusion with the "fire plan" that fire fighters develop after assessing the situation and before actual fire fighting.
[86] Response to Data Request #492.
[87] Response to Data Request # 467

Liberty was concerned that an electrical shock hazard might exist at the standpipe during faults on substation equipment or lines. Liberty suggests that ComEd determine how to prevent excessive touch potential at the standpipe.[88]

Also, the during October 2006, February 2007, and July 2007 inspections for compliance to the battery cable relocation program at three substations, Liberty observed that certain 48 V station batteries appeared to be smaller than batteries located at some other TDC substations of similar size. Substation batteries supply control and indication power.. An undersized battery could prevent the remote operation of important substation equipment in emergency conditions. ComEd conducted capacity studies, based on IEEE[89] Standard 485, for the batteries in the three substations, and found that the capacities of all three of these batteries did not meet current ComEd standards. ComEd completed these studies in June and July 2007. ComEd reported that it is replacing these batteries with higher capacity batteries, and is conducting battery capacity studies on 25 other TDC substations with 48 V batteries. ComEd intends to complete these studies by the end of 2007.[90]

As of August 2007, Liberty found that ComEd is complying with its response and is on schedule for completing the fire prevention fieldwork for substations similar to Downers Grove. However, this action item remains open. Liberty will continue to verify the progress of the substation fire-prevention program. In addition, Liberty will review issues related to the grounding of standpipes and battery capacity.

2. Substation Prioritization

ComEd's response indicated that its plan addresses the priority of implementing fire protection improvements at substations using a method similar to the method suggested in Liberty's report.[91] ComEd based its prioritization on:

- Potential for stranded load during peak load conditions
- Number of cable joints
- Percent of poly (plastic) feeder cables[92]
- Number of critical customers at each substation
- Percent of unfilled penetrations
- Substation load
- Number of substation circuits.

Liberty verified that ComEd ranked its cable space substations for fire prevention work based on a formula that included the factors listed above. ComEd listed its cable space substations by this ranking system, by peak loading ranking, by a Liberty-derived method, and by the average of all rankings. ComEd used these rankings to determine priorities and scheduling of its ComEd 2006-

[88] Interview, Fire Protection, July 24, 2007.
[89] Institute of Electrical & Electronics Engineers.
[90] Interview, Substation Engineering, August 7, 2007.
[91] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[92] These cables are more susceptible to fires.

2007 substation fire prevention work as indicated in ComEd's fire protection projects management tool.[93]

Liberty considers this commitment verified and closed; ComEd prioritized its substations for the fire prevention work as indicated in its response.

3. Substation Inspections

ComEd's response to Liberty's recommendations indicated that it conducted visual inspections and inventoried the condition of over 100 substations with cable spaces. It used the information obtained from the inspections to plan the work required and in the prioritization discussed immediately above.[94]

Liberty verified that ComEd completed the inspection of 110 substations with the potential for cable spaces by November 18, 2005. Seven of these substations did not have cable spaces. One cable space substation was the Downers Grove substation, where fire prevention improvements were complete. ComEd inspected and inventoried the remaining 102 substations. Inventory questions included: [95]

- Are there battery cables routed in the cable space?
- How many sets of cable joints are located in the cable space?
- How many penetrations are filled and not filled? What is the percentage filled?
- Is fire detection equipment installed?

Liberty considers this commitment verified and closed.

4. Thermographic Inspections

ComEd's response indicated that it performed thermographic (infrared) inspections at 83 substations that contain poly (plastic) cables and joints; it made repairs on circuits that have shown "hot spots" at these substations.[96] By the end of 2006, ComEd said that it would perform thermographic testing at approximately 70 additional TSS and TDC cable space substations. By the end of 2007, it will review substation layouts to determine if there are additional cables spaces. ComEd will thermo-scan any additional cable space areas identified during this review.[97]

Liberty verified that by January 31, 2006, ComEd performed thermographic inspections on cable joints in cable spaces in 83 substations. ComEd replaced eight first section cable runs and two lead joints because of hot joints identified by the thermographic inspections. ComEd also identified other non-joint related problems with this program. [98]

[93] Response to Data Request # 424.
[94] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[95] Response to Data Request # 423.
[96] Infrared thermography is a thermal analysis tool used for preventive maintenance. An inadequate cable joint could be detected by causing a temperature reading higher than the adjacent cable.
[97] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[98] Response to Data Request # 426.

Liberty verified that during March and April 2006, ComEd completed the thermographic inspections on 67 additional substations.[99] ComEd reported that it has conducted a drawing review of its substation layouts to identify substations that might have cable spaces. ComEd said that it is performing field inspections, which will be complete by the end of 2007.[100]

Liberty considers all action items verified and closed, except for one. Liberty will later verify whether ComEd performed the substation field inspections by the end of 2007 for possible additional cable spaces.

[99] Response to Data Request # 467.
[100] Response to Data Request # 428, and Interview, Fire Prevention Manager, October 12, 2006.

VI. Dispatcher and Operator Training

A. Recommendation

The fire at the Downers Grove substation revealed weaknesses in the manner in which ComEd responded to the emergency. Specific areas were acknowledgement of fire alarms at the Operations Control Center (OCC), clear instructions for Customer Service Representatives (CSR), division of authority between the OCC and Transmission System Operations (TSO), and de-energization of equipment. Liberty recommended that ComEd should:

- Improve dispatcher and operator training and qualifications related to substation fires, including instilling in its load dispatchers the expediency of returning system configurations to normal, de-energizing equipment under proper circumstances, acknowledging alarms, and absolute decision-making authority over the areas of the system for which they have jurisdiction.
- Train its Customer Service Representatives to be clear about whether a structure fire exists.
- Re-evaluate the priority given to substation fire alarms and the actions that dispatchers take after receiving such an alarm.
- Develop mechanisms that would reduce the verification time in determining that a fire exists at one of its substations.
- Have on-site accessible site fire plans and a direct access number to the dispatcher for fire personnel.

B. ComEd's Response and Liberty's Verification

ComEd agreed with the recommendation and stated it would take several actions to strengthen training for operations personnel and to raise the awareness of the actions that its personnel should take during off-normal conditions such as a substation fire.

1. Substation Fire Response Procedure Training

ComEd reported[101] that several fire-response training initiatives were underway. ComEd issued a "First Responder" procedure on June 30, 2005. ComEd trained the incident commanders on the procedure; ComEd indicated that it would train Operations' field personnel by July 1, 2006.

ComEd also reported that it implemented a change to the way that the TSO and OCC respond to substation fire alarms. ComEd will contact 911 immediately to initiate an emergency response upon notification of a substation fire alarm along with other equipment operations or loss of telemetry. ComEd committed to developing procedures that require the OCC and TSO to coordinate their responses to fire alarms and [redacted][102] fire calls by March 1, 2006.

[101] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[102] [redacted].

ComEd also recognized that it must improve communications with firefighting organizations. ComEd has reinforced to local fire departments and [redacted] that the OCC is the single point of contact (SPOC). ComEd notified [redacted] of this in September 2005 and ComEd sent out letters to nearly 400 Fire Chiefs and Fire Protection Districts in December 2005. [103]

ComEd issued a first responder procedure, OP-ED-4007 Rev. 0, on June 30, 2005. This procedure included detailed instructions for the customer care center, dispatchers, and first responders. ComEd revised that procedure on April 1, 2006, to include additional direction for first responders and to enhance communications between them and police and fire departments when responding to emergency police and fire calls for structure fires. However, this procedure did not specifically call out a substation fire.[104] ComEd provided a printout indicating that 25 ComEd groups received training on procedure OP-ED-4007, "Response to Police/Fire Calls;" ComEd completed the training on April 12, 2006.[105] ComEd's procedure OP-ED-4001, Revision 3, issued on February 1, 2006, requires that the OCC/TSO Designated Authority (dispatcher) contact the other OCC/TSO dispatcher using 3-way communication, verifying the awareness of the OCC/TSO receiving a fire alarm. It also requires that ComEd call 911 or [redacted] for the Chicago region.[106] ComEd provided Liberty with a copy of the form letter and attachment, dated December 5, 2005, mailed to fire chiefs and fire protection districts instructing them to call the ComEd call center or the OCC using the phone numbers provided. Instructions in the letter indicated that fire departments should use the OCC phone number for communications regarding ComEd electrical facility fires. ComEd verified that it had verbally notified [redacted], its Chicago alarm service at that time, in September 2005, that the OCC is the SPOC, and provided [redacted] with the OCC's telephone number. After [redacted] regarding how to contact the OCC and provided OCC telephone numbers.[107]

Liberty considers this commitment verified and closed.

2. Division of Authority between the OCC and the TSO

During November 2005, ComEd reported that it held meetings with Transmission and Distribution Operations to reinforce that Operations Shift Managers have the authority and responsibility to de-energize equipment, and determine the necessary extent of equipment isolation in the event of fire or catastrophic event.[108]

ComEd provided various internal memoranda and policies pertaining to the absolute authority of the Operations Control Center and Transmission System Operations to de-energize equipment under their dispatch control.[109]

Liberty considers this commitment verified and closed.

[103] Response to Data Request #430.
[104] Response to Data Request #441.
[105] Response to Data Request #442.
[106] Response to Data Request #436.
[107] Response to Data Request #429.
[108] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[109] Response to Data Request #431.

3. CSR[110] Fire Response Procedure Improvement

In its response to Liberty's 2005 report, ComEd reported that it was re-evaluating and modifying the CSR process for providing accurate and timely information related to substation emergencies in order to capture the immediate attention of the Operating Dispatcher. ComEd also indicated that it would establish a 3-way communication acknowledgement process.[111] ComEd committed to complete this by March 1, 2006.[112]

ComEd revised the documentation that CSRs use during emergencies such as a substation fire. In part, that documentation consisted of a CSR Quick Reference–Electric Trouble page dated February 21, 2006, that requires a CSR to respond to a fire in a ComEd substation on an immediate basis and process the event on a "Structure Fire" trouble ticket. The documentation also included the Care Center Emergency Response dated February 17, 2006,[113] which details the information a CSR should obtain if injuries to the public or ComEd people are involved. In addition, ComEd gave the CSRs substation photographs depicting various layouts and configurations.[114]

With regard to 3-way communications, ComEd provided procedure OP-ED-010005, which establishes the 3-way communication process to be used throughout EED[115] to ensure that communications are clear, concise, complete, and free of ambiguity for decision-making purposes.[116] The procedure requires 3-way communications for information exchanges that result in decision-making, actions taken, or direction given. The procedure was first effective in April 2004 and revised in June 2005, both prior to the fire at the Downers Grove substation.

Neither the CSR Quick Reference-Electric Trouble page nor the Care Center Emergency Response mentioned the use of 3-way communications by CSRs. ComEd revised these documents on September 19, 2006, to require that CSRs use proper 3-way communication techniques.[117]

In addition, ComEd supplied documentation in the form of Field Bulletin FBE[118] 06-039, effective June 2, 2006, which reinforced the use of 3-way communications during emergent work between the Designated Authority and all field personnel. ComEd also supplied Field Bulletin FBE 06-09, effective June 15, 2006, which clarifies the specific 3-way communication process used when issuing and releasing clearances under equipment lockout and tag out procedures.[119]

[110] CSR is Customer Service Representative.
[111] "3-way communication" or "3-part communication" involves reporting back information or direction so that both parties have a clear and consistent understanding.
[112] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[113] Date on the computer file, not the document itself.
[114] Response to Data Request #435.
[115] EED is Exelon Energy Delivery.
[116] Response to Data Request #187.
[117] Response to Data Request #435 Supplement.
[118] FBE is a numbering designation Exelon Energy Delivery gives to field bulletins.
[119] Response to Data Request #435 Supplement.

Liberty concluded that ComEd met its commitment with regard to modifying the CSR process to provide accurate and timely information related to substation emergencies. However, the 3-way communication acknowledgement process that ComEd said it would establish by March 1, 2006, was already in place at the time of the Downers Grove fire and when ComEd made its commitments. Poor communications were evident during the Downers Grove fire emergency and Liberty recommended that ComEd train its area operators and dispatchers in communicating in a clear and concise manner. ComEd reinforced this process with field personnel in June 2006 and updated the CSR guidance related to the reinforcement of 3-way communications in September 19, 2006. Therefore, Liberty found that ComEd did not meet the date of its commitment in this regard.

Liberty concluded that ComEd met its commitments except for being late with regard to reinforcing the use of proper communications with CSR personnel. Liberty's verification of this commitment is complete.

4. Substation Fire Drills

ComEd said that it would perform drills that will include a scenario for a substation fire. ComEd also committed to hold drills periodically and involve Site Restoration Management, Operations and Load Dispatchers, Area Operators, and other departments as applicable. ComEd will invite local fire department(s) to participate in the appropriate portions of the drill. Lessons learned from these drills will be cascaded through the organization. ComEd indicated that it would hold the first drill by May 1, 2006.[120]

ComEd held its first (since the Downers Grove fire) substation fire drill at Arlington Heights (TDC 268) on April 19, 2006. Liberty witnessed the drill from the OCC and from the substation. The drill scenario had similarities to the actual Downers Grove cable-space fire. ComEd provided procedure EP-ED-8003 (Emergency Response Drill Administration) Revision 3, dated September 19, 2006, procedure EP-ED-3008 (Event Lessons Learned procedure) Revision 3, dated September 19, 2006, and a copy of the Drill Lessons Learned Summary constructed after the April 19, 2006 drill.[121]

ComEd conducted its second substation fire drill at Glendale Heights (TDC 562) on May 2, 2007. Liberty did not witness this event but interviewed the drill's program manager and reviewed the drill scenario and lessons learned.[122]

Liberty considers this commitment verified, however this action item remains open to monitor future drills.

5. Fire Alarm Recognition and Priority Improvement

ComEd reported that it initiated improvements for the dispatcher and operating departments to reduce fire response times. ComEd has modified the priority of fire alarms from priority two (2)

[120] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[121] Response to Data Request #439.
[122] Response to Data Request #485.

to priority one (1). Starting January 13, 2006, both Transmission Systems Operations (TSO) and distribution Operations Control Center (OCC) receive fire alarms from the same substation, where previously ComEd segregated the transmission and distribution substations. In addition, SCADA fire alarms received at the OCC have a unique audible sound. ComEd said that it completed this action on January 20, 2006.[123]

ComEd provided a copy of the SCADA screen that depicts the priority of fire alarms and various internal memoranda relating to treatment and acknowledgement of substation fire alarms.[124]

Liberty considers this commitment verified and closed.

6. Site Fire Plan Creation

To assist firefighters, ComEd will create site fire pre-plans for TSS and TDC substations and applicable transmission tunnels. These plans will include descriptions of fire systems, hazards, site geographic layouts, and 24-hour emergency contact numbers. The plans will be on file at the site. ComEd is contracting with an industry consultant for development of these site fire plans. ComEd said it would complete all TSS and TDC Chicago stations by the end of 2007; it will complete TDC substations similar to Downers Grove by 2008. ComEd plans to install site fire plans at all substations with a building containing electrical power equipment or relay control equipment by the end of 2011.[125]

ComEd provided contract documents with an industry site fire-plan consultant and a list of substations that had fire plans completed by September 29, 2006.[126] That document showed that 30 substations had completed site fire plans.

In August 2007, ComEd provided an update to their schedule of fire plan creation.[127] That document listed the progress that ComEd is making and the future schedule by date and by substation. As of July 27, 2007, ComEd:

- Completed 65 site fire plans in 2006
- Completed 39 site fire plans 2007
- Has 51 site fire plans remaining to complete in 2007
- Scheduled 66 site fire plans for completion in 2008, 73 for 2009, and 59 for 2010.

On their current schedule, ComEd should complete creation of site fire plans by the end of 2010, one year prior to their commitment. Liberty's verification of this commitment is not complete. Liberty will monitor ComEd's progress on this action item.

[123] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[124] Response to Data Requests #432, #433, and #434.
[125] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[126] Responses to Data Requests #443, #444 and #446.
[127] Response to data request #492.

7. Operation of Circuit Switchers and Circuit Breakers

ComEd reported that it would investigate and determine whether it can manually open circuit switchers and circuit breakers under load and fault conditions without DC control power. Based on the results of this technical investigation, ComEd will develop a technical document for the manual operation of circuit switchers and circuit breakers by March 1, 2006. ComEd will then determine the switching operations that it can perform in accordance with work practices and safety guidelines. If determined acceptable, training documents will be prepared by April 1, 2006. ComEd will also train personnel on manual equipment operations that they can perform without DC control power. ComEd will complete this by June 1, 2006.[128]

ComEd's Tech Bulletin TB-06-007, effective February 28, 2006, "Opening a Circuit Switcher Using its Manual Hand Crank in Emergency Situations," addressed the capability to open a circuit switcher under load conditions using its manual hand crank in emergency conditions. In summary, it stated that personnel could use the manual hand crank to open a circuit switcher under load conditions but not to clear a fault. Manual operation of a circuit switcher may only take place under the direction of the TSO or OCC Load Dispatcher.

ComEd's Tech Bulletin TB-06-014, effective February 28, 2006, "Circuit Breaker Manual Operation," addressed the capability to open circuit breakers manually without DC power. The bulletin indicated that manual opening of circuit breakers may take place under load and fault conditions provided the circuit breaker is in good operating condition and the required pressures or gas densities are above minimum values.[129]

Additional, relevant documents that ComEd provided were:[130]

- OP-ED-3332032, Revision 0, effective March 24, 2006, and titled "Opening Circuit Switchers Under Load Using Manual Hand Crank Under Emergency Conditions."
- CM-ED-332008, Revision 0, effective September 8, 2005, and titled Circuit Switcher Operation and Response to Targets.
- OP-ED-332031, Revision 0, effective March 24, 2006, and titled Emergency Tripping of Circuit Breakers without DC Power.
- OP-CE-400002, Revision 0, effective February 10, 2006, and titled De-Energizing Substation Equipment Involved in a Fire.

ComEd supplied records on training for OP-ED-332031 and OP-ED-332032 conducted during the months of April 2006 and May 2006. These records showed that of the 142 people at the OCC, 57 were required to take the emergency switching training and that all had done so by June 1, 2006. ComEd also supplied documentation that showed that 158 field personnel were required to take the emergency switching training (by job classification) and that 151 had done so by June 1, 2006. Of the seven who had not completed the training by June 1, 2006, four were maintenance only personnel who do not perform switching, one was on long-term disability, one

[128] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[129] Response to Data Request #437.
[130] Response to Data Request #438, Supplement.

had not started in the field until December 2006, and one was not working in the field at the time.[131]

During the week of July 24, 2006, and in response to potential safety concerns that ComEd personnel raised, ComEd deleted OP-ED-332031 – Emergency Tripping of Circuit Breakers without DC Power – from the management model. ComEd reissued Tech Bulletin TB-06-014 – Circuit Breaker Manual Operation, which now stated that due to "line of fire" and personnel safety concerns, ComEd would not adopt the practice of manually tripping a circuit breaker to de-energize a facility. ComEd's decision to not manually open circuit breakers appears to be based on feedback from in-house personnel who are familiar with ComEd historical practices. It appears that ComEd did not base the decision on any technical study or opinions from outside vendors or other experts.[132] Liberty believes the basis for ComEd's reversal of the decision to operate circuit breakers manually was technically weak.

Liberty concluded that ComEd investigated manually opening of circuit breakers and circuit switchers without DC power, developed technical documents for manual operation of circuit breakers and circuit switchers by March 1, 2006, prepared training documents by April 1, 2006, and trained switching personnel on manual operation of these devices by June 1, 2006.

Liberty considers this commitment verified and closed.

[131] Response to Data request #440 Supplement.
[132] Response to Data request #438.

VII. Risk-Based Analysis of Substations

A. Recommendation

Liberty recommended that ComEd conduct a risk-based analysis of all substations and make appropriate plans for the recovery of substations assuming a total loss of all substation equipment**.** ComEd should review all of its substations to identify substations that may be vulnerable to extended customer outages and the possible causes of those outages. ComEd should know where the system is vulnerable and have at least conceptual plans for dealing with a total substation loss. As part of this review, ComEd should review its portable equipment inventory to determine if additional equipment in this inventory would be beneficial.

B. ComEd's Response and Liberty's Verification

In its response, ComEd agreed with an alternative approach. ComEd said that it should approach this type of analysis differently for substations that serve transmission load only and for those that serve distribution customers directly because a greater variety of dynamic conditions affect substations that serve transmission load.

ComEd said that for substations that serve distribution load directly, it developed a strategy to address the complete loss of a substation with three focused objectives. First, ComEd categorized each substation based on the effect to customers of a total loss of the substation. Second, for each substation, ComEd developed initial restoration plans with a set of pre-planned restoration options. Third, ComEd used the effect on customers of a total substation outage so that ComEd management could evaluate mitigation options.

ComEd said that for substations that serve transmission load, it performed studies on the system that are highly dependent on many operational assumptions. These assumptions include, for example, which transmission lines are in-service, which generating stations are on-line, and how much power is being transferred between companies or regions. If one or more of these study assumptions does not match real time operations, the results may not be applicable. ComEd suggested that it approach the loss of a transmission substation from a broad perspective rather than performing system studies and developing substation specific transmission restoration plans for each individual transmission substation.

1. Single-Transformer Distribution Substations

ComEd said that by June 1, 2006, it would develop operational contingency plans for the total loss of each single-transformer distribution substation (TSS, TDC, SS, and DC) supplied by voltages between 12 kV and 138 kV. These contingency plans were to include the identification of switches that operators would use to complete customer restorations and, where 100 percent of customers cannot be transferred to other sources, the identification of the number and sizes of mobile transformers or generators needed to complete customer restorations. ComEd planned to include these plans in a database used by Operations as guides to determine restoration steps.[133]

[133] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

Liberty verified that by May 30, 2006, ComEd developed contingency plans for the total loss of each single-transformer distribution substation.[134] Liberty reviewed a ComEd document that contained restoration strategies for the complete loss of each single-transformer distribution substation, and single transformer terminals at multiple-transformer distribution substations. ComEd based these contingency plans on 90/10 summer weather[135] with a normal system configuration. Each plan sheet indicated basic substation information, the review date, the planner, and loads under different conditions. The plan sheets also indicated tie switch identification and capacities, switching instructions, and mobile equipment use and connection location possibilities. ComEd said that it would review the single-transformer substation restoration strategies annually. ComEd also indicated that it reviewed the results of its analysis with ComEd's senior management.

Liberty and ComEd reviewed the database and how ComEd might use it at the OCC during emergencies.[136] The database lists all single-transformer distribution substations, provides data such as projected loads and transfer capability for each, and provides notes and contingency comments that could be useful if there was a problem at a substation. For example, the database identifies switches/tie points for load transfer and places where ComEd may be able to connect mobile generators. The Planning group updates the database and provides it to the OCC by July 1 of each year.

Dispatchers do not use the database directly; Emergency Response personnel, Shift Managers, and System Engineers would be the likely users. This tool started as strictly a planning document but now also serves a useful operations purpose.

Liberty considers this commitment verified and closed.

2. Multiple-Transformer Substations – Transfer Capability

ComEd said that by July 1, 2006, it will have determined the transfer capability to adjacent substations for each multiple-transformer distribution substation (TSS, TDC, SS, and DC) at 90th percentile summer weather and during off-peak periods, assuming a total substation outage.[137]

Liberty verified that ComEd completed its determination of the transfer capability of multiple-transformer substations on June 15, 2006. ComEd considered load-transfer capacity for both summer-peak and off-peak conditions.[138]

Liberty verified that these data are available at the OCC and discussed with ComEd how the OCC might use them during emergencies.[139]

[134] Response to Data Request #447, and interview, Director Capacity Planning, and Operations Planning Manager, Oct 11, 2006.
[135] 90/10 or 90th percentile summer weather is the extreme weather conditions expected to occur only once every ten years.
[136] Interview, OCC, February 20, 2007.
[137] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[138] Response to Data Request # 448, and interview, Director Capacity Planning, and Operations Planning Manager, Oct 11, 2006.

Liberty considers this commitment verified and closed.

3. Multiple-Transformer Substations – Categories

ComEd reported that by July 1, 2006, it will have categorized each multiple-transformer distribution substation based on complete substation outage risk and possible restoration options. The purpose of the categorization was to allow for timely communication of the potential customer effect and determination of a possible, initial restoration strategy.[140]

Liberty verified that prior to the commitment date ComEd had categorized its multiple-transformer TDC/TSS and SS/DC distribution substations into four categories. ComEd based the categories on the amount of load at risk (feeders without ties to other substations) during 90/10 summer peak and during off-peak loads. The general strategies developed for each category included the use of mobile transformers and generators, the identification of cable cuts and temporary feeder ties, and indicating the possibility of rotating load curtailments.[141]

Liberty verified that these data are available at the OCC and discussed with ComEd how the OCC might use them during emergencies.[142]

Liberty considers this commitment verified and closed.

4. At-Risk Distribution Customers

ComEd responded that by October 1, 2006, it will have identified the number of customers at risk and critical customers at multiple-transformer distribution substations that do not have 100 percent transfer capability during 90th percentile weather.[143]

An information database developed after the Downers Grove substation fire was an identification of the customers at risk (i.e., cannot be transferred) and critical customers at multiple transformer substations. ComEd demonstrated how this information was available to, and could be used at, the OCC. The "critical customer" list includes customers such as managed accounts, schools, public utility facilities, and health facilities. During the substation fire drill in April of 2006, it was noted that this list was not categorized so that, for example, hospitals could be quickly identified. The list now is categorized and color-coded for improved usefulness.

Liberty considers this commitment verified and closed.

[139] Interview, OCC, February 20, 2007.
[140] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[141] Response to Data Request #449, and interview, Director Capacity Planning, and Operations Planning Manager, Oct 11, 2006.
[142] Interview, OCC, February 20, 2007.
[143] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.

5. Feeders without Direct Ties to Other Substations

ComEd said that by July 1, 2006, it will have identified the feeders at multiple-transformer distribution substations that do not have direct ties to feeders from other substations. ComEd said it would provide the list to Operations for emergency response restoration efforts.[144]

Liberty verified that by June 15, 2006, ComEd developed a document that identifies feeders from multiple-transformer substations that do not have direct ties to feeders originating from other substations.[145] ComEd said that it provided the listing to Operations.

Liberty verified that these data are available at the OCC and discussed with ComEd how the OCC might use them during emergencies.[146]

Liberty considers this commitment verified and closed.

6. Distribution Substation Restoration Options and Tools

ComEd's response indicated that by December 1, 2006, it will have developed a set of restoration options and tools for multiple-transformer distribution substations that can be deployed to assist in restoring customers as a result of catastrophic substation outage or supply-side interruptions. These restoration options and tools will include determining field connections for mobile 34 kV-12 kV transformers, determining the appropriate levels of mobile equipment, and evaluating the use of 12 kV mobile switchgear.[147]

ComEd provided a package of information that documented its work on this commitment.[148] This information had four main parts:

- Evaluation of the possible use of mobile switchgear.
- Determination of appropriate levels of mobile equipment.
- A procedure for using portable 34 kV to 12/4 kV transformers.
- Strategy for repair of damaged transmission lines.

Liberty discusses each of these four topics below. Overall, Liberty concluded that ComEd met its commitment, but that ComEd should improve its analyses and evaluations to meet the intent of the commitment. Liberty will keep this item open for future review of any changes that ComEd may choose to make.

Mobile Switchgear

ComEd concluded that it should not purchase 12 kV mobile switchgear. In part, the basis for this conclusion was that it would take five days to deploy and energize mobile switchgear. Even with

[144] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[145] Response to Data Requests # 451 and 452.
[146] Interview, OCC, February 20, 2007.
[147] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[148] Response to Data Request #455 Supplement.

the most significant historical bus damage experienced by ComEd, the company could rebuild and return to service undamaged equipment more quickly than deployment of mobile switchgear.

ComEd contacted 13 potential manufacturers of a mobile switchgear facility. None of them had such equipment available for rent. Several indicated a price for building such a facility.

Finally, ComEd indicated that by using equipment designated for new construction or future additions, it could "put together" switchgear for restoration of damaged equipment.

Liberty found that ComEd's analysis of whether to have portable switchgear available for emergencies was not convincing for several reasons. First, ComEd's foundation was the most significant historical damage it had experienced. The commitment clearly was to evaluate a catastrophic failure of an entire substation. ComEd's Downers Grove substation fire was the basis for the worst historical event. However, personnel who studied the Downers Grove fire know that it could have had much worse consequences (customers being out of service for longer periods) simply by having more switchgear and bus damage for the circuits that ComEd could not tie to other substations. Moreover, the intent of the recommendation, and supposedly ComEd's response, was to evaluate possible substation catastrophes that could occur for reasons unrelated to the Downers Grove event.

ComEd's work in other areas shows that there are many feeders (customers and loads) that it cannot switch to another substation. Indeed, there were many customers served by Downers Grove that only regained power after ComEd cleaned and made ready for use undamaged switchgear in that same substation.

ComEd calls its five-day schedule for mobilizing portable switchgear a best case. Whatever the mobilization schedule is, however, ComEd should compare it against the time that customers may be out of service, assuming the total substation loss and not having such mobile switchgear available.

Liberty thinks that ComEd should rethink its analysis. It should assume a lower probability, catastrophic loss of a substation that results in being unable to use existing substation equipment. ComEd should determine the consequences and then the appropriate question is whether ComEd is willing to assume the risk of those consequences, what are the alternatives to mitigate the consequences, and whether it is cost-beneficial to have additional facilities such as 12 kV mobile switchgear available. Liberty is not recommending that ComEd purchase or arrange for mobile switchgear. Rather, ComEd should analyze the question correctly as worded.

Appropriate Levels of Mobile Equipment

ComEd indicated that it owns some 2MW mobiles generators and has a contract with a company to rent additional 2MW mobile generators. [redacted]

ComEd also indicated that it is assembling field connection packages (cable and cutouts) to facilitate the connection of these generators. ComEd has scheduled miscellaneous hardware to complete the connection packages by the first quarter of 2007.

ComEd's work to facilitate field connection of mobile generators is a positive step from lessons learned during earlier events.

Liberty concluded that ComEd's analysis of the number of mobile generators was more of an examination of current capabilities rather than a determination of the appropriate level of mobile equipment.

Procedure for Using Portable 34 kV to 12/4 kV Transformers

ComEd issued procedure CM-CE-890021 with an effective date of November 26, 2006. It provides instructions for the setup, operation, and removal of specific portable transformers, which ComEd calls portable unit substations. The procedure did not exist before November 2006. It appears to be very detailed and complete.

It is not clear whether ComEd may need or already have procedures for other portable equipment, such as mobile generators and different portable transformers.

Strategy for repair of damaged transmission lines

ComEd presented the results of a study it performed to set out a strategy for repairing catastrophically damaged transmission lines. It divided the transmission system into five categories:

- Class I – 69kV and 138kV single pole or H frame wood lines
- Class II – 138kV steel structure or tubular steel lines
- Class III – 345kV short span on steel towers or tubular steel lines
- Class IV – 345kV long span cross country steel tower lines
- Class V – 765kV long span steel tower lines.

ComEd then addressed the overall repair strategy, what emergency materials are available, whether the amount of supplies is adequate, and whether the design facilitates expeditious restoration.

Available transmission stocks and their use within each of the five transmission classes appear adequate. However, the evaluation may not have gone far enough. For example, dead-end and angle structures are not part of the emergency stock; ComEd stated these would be available from other utilities through mutual assistance agreements in place through EEI and PJM.[149] Foundation emergency reserve stock requirements are minimal since most of the emergency structures have direct imbedded shafts. These would only require gravel or ready-mix concrete for the foundation materials, both of which are readily available. ComEd thoroughly examined

[149] EEI is the Edison Electric Institute, an association of shareholder-owned electric utilities. PJM is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states.

each class strategy separately and assumed the use of stock from other transmission classes as required. It is not clear that if a catastrophic event damages more than one class on a given right-of-way, the supplies will be adequate. ComEd uses its wood pole structures as temporary alternative construction to some other transmission class types but notes that their use may not be possible on a given right-of-way. ComEd should consider what non-typical construction it would need to use in limited right-of-way cases and consider whether it should purchase stocks of those materials.

7. Communication of Distribution Substation Risk Assessment

ComEd's response indicated that by October 1, 2006, it will have developed documentation to define and communicate the categorization of multiple-transformer distribution substations based on transfer capability and restoration strategies. ComEd also indicated that by January 1, 2007, it will have communicated the categorization/risk assessment, highlighting distribution substations where there is the greatest probability of extended interruptions given current strategies. ComEd reported that it had already developed complete outage recovery plans for some of these substations.[150]

In October 2006, Liberty verified that ComEd has documentation on the categorization of substations.[151] Liberty also verified that ComEd had already developed some outage recovery plans.[152]

In August 2007, ComEd provided documentation showing that it communicated the distribution substation risk-assessment during a staff meeting held on October 2, 2006. Participants included ComEd's Technical Services and Support Organization Vice Presidents, and others. The discussion included substation categorization, load transfer capabilities and deficiencies of critical substations during normal and peak load conditions, available portable generation capabilities, and restoration issues. ComEd reported that it reviewed the risk assessment with a new vice-president in place subsequent to the October 2, 2006, staff meeting, that it intended to review the status of the assessment as needed, and that it has an operating procedure for using its substation categorization based on load at risk.[153, 154]

Liberty considers this commitment verified and closed.

8. Transmission Substation Categories

In its response, ComEd said that by June 1, 2006, it would have categorized each transmission substation into one of three categories based on the impact to system security following a total loss. The results of this work will provide operators guidance as to relative importance of each transmission substation to the reliability of the transmission system. The first category will contain transmission substations where a large part of the transmission system might be lost on

[150] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[151] Response to Data Request #453.
[152] Interviews, February 14 and April 20, 2006.
[153] Interview, Asset Performance Director, August 8, 2007.
[154] Response to Data Request #456.

an uncontrolled basis for a total outage at peak load. The second category will contain transmission substations where it would need to shed customer load to prevent additional damage to transmission equipment. The third category will contain transmission substations where the transmission system would remain intact and there would be no stranded distribution load.[155]

In October 2006, Liberty discussed with ComEd the work completed on this commitment.[156] Liberty reviewed how ComEd determined the three categories and applied them to transmission substations. During February 2007, Liberty again discussed this action item with ComEd and reviewed the web site that is available to Transmission Operations Shift Managers and Emergency Restoration Managers at the TSO.[157] ComEd demonstrated how these personnel could call up the list of critical substations and see the classification of each.

Liberty considers this commitment verified and closed.

9. Transmission Substation Restoration Guide

In its response, ComEd said that by the end of 2006 and following the categorization assessment, it would produce a process document to guide transmission system operations following an event. The document was to include roles and responsibilities, emergency contact information, and reference to emergency procedures. In addition, ComEd said it would create a checklist of items to consider during the event and train Transmission Operations Shift Managers and Emergency Restoration Managers on this procedure by the end of 2006.[158]

In October 2006, Liberty discussed with ComEd the work completed on this commitment.[159] Liberty reviewed how ComEd planned to complete the development of a web site process document that it could use during transmission system operational events. During February 2007, Liberty again discussed this action item with ComEd and reviewed the web site that is available to Transmission Operations Shift Managers and Emergency Restoration Managers at the TSO.[160] ComEd demonstrated how this tool includes roles and responsibilities, emergency contact information, and links to procedures that it may need to use. ComEd used the new tools during three recent storm events.

Liberty also reviewed a "Transmission Operations & Planning, TSO ERM Handbook,"[161] dated November 1, 2006, a revised TSO Emergency Response Manager Checklist, dated November 21, 2006, and evidence of completed training on the new Handbook.[162] All transmission Shift Managers and ERMs completed the training before the end of 2006.

Liberty considers this commitment verified and closed.

[155] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[156] Interview, Director Transmission Planning, October 19, 2006.
[157] Interview, Director Transmission Planning, February 14, 2007.
[158] ComEd's Response to the 2005 Liberty Report Recommendations, February 3, 2006.
[159] Interview, Director Transmission Planning, October 19, 2006.
[160] Interview, Director Transmission Planning, February 14, 2007.
[161] TSO ERM stands for transmission system operations Emergency Response Manager.
[162] Response to Data Request #460, Supplement.