RAPPORT D’AUDIT DU NERC (2005-2006)
Reliability Coordinator, Balancing Authority, and Transmission Operator
Reliability Readiness Audit Report

Hydro-Québec TransÉnergie

October 25–28, 2005
January 17–19, 2006

Montreal, Quebec

North American Electric Reliability Council
# Table of Contents

Introduction and Audit Process ................................................................. 1  
Audit Team .......................................................................................... 1  
Organization Profile ........................................................................... 2  
Executive Summary .......................................................................... 3  
Potential Examples of Excellence ....................................................... 3  
Positive Observations ....................................................................... 3  
Recommendations ............................................................................. 4  
Discussion ......................................................................................... 5  
1. Agreements .................................................................................. 5  
2. Standards of Conduct/Independence ........................................... 6  
3. Operator Authority ...................................................................... 7  
4. Delegation of Authority .............................................................. 8  
5. Staff Certification ...................................................................... 9  
6. Training ...................................................................................... 9  
7. Operating Policies and Operating Procedures ......................... 11  
8. Planning .................................................................................... 12  
9. Outage Coordination and Communication .............................. 15  
10. Plans for the Loss of Control Facilities .................................... 16  
11. Tools ....................................................................................... 17  
12. Real-Time Monitoring ............................................................... 19  
   a. System Visibility .................................................................... 19  
   b. Alarms .................................................................................. 19  
   c. Frequency ............................................................................ 20  
   d. Voltage ............................................................................... 20  
   e. Reactive Reserve .................................................................. 21  
   f. Critical Facilities ................................................................... 22  
   g. Transmission System Congestion ....................................... 23  
   h. Load Generation Balance .................................................... 23  
   i. Contingency Reserves .......................................................... 23  
   j. Special Protection Systems ................................................. 24  
13. System Restoration ................................................................. 25  
14. Equipment Maintenance and Testing ........................................ 26  
15. Capacity and Energy Emergency Plan ..................................... 26  
17. Nuclear Power Plant Requirements ........................................ 28  
APPENDIX 1: Critical Energy Infrastructure ................................. 30  
APPENDIX 2: Audit Participants ...................................................... 31  
APPENDIX 3: Documents Reviewed ................................................ 32
Introduction and Audit Process
The North American Electric Reliability Council (NERC) Reliability Readiness Audit and Improvement Program is one of the commitments of NERC and the industry following the blackout of August 14, 2003, to strengthen the reliability of the North American bulk power supply system. The program provides independent audits of balancing authorities, transmission operators, reliability coordinators, and the associated planning organizations to assess their preparedness to meet the assigned reliability responsibilities. The audit identifies both strengths and areas for improvement in an effort to promote excellence in operations among these organizations.

The document NERC Readiness Audit Procedure describes and defines the process used for readiness audits of existing reliability coordinators, balancing authorities, and transmission operators. This and other documents related to the program are available at http://www.nerc.com/~rap/.

The reliability readiness audit teams, each led by a NERC staff member and a regional co-leader, include industry volunteers with considerable expertise selected to provide representation from other interconnections, other regions, and neighboring operating entities. The teams also typically include representatives from the Federal Energy Regulatory Commission (FERC) staff. For the audit of Hydro-Québec TransÉnergie (HQ-T), members of the Régie de l’énergie Québec were invited to participate as the regulatory agency for HQ-T.

The public version of the reliability readiness audit report contains the majority of the audit team findings. Any discussion of findings pertaining to critical energy infrastructure will be contained in Appendix 1, a confidential appendix to the report that is sent privately to the organization audited and is not included in the public version of the report.

The audit team for the HQ-T met on site with HQ-T representatives on October 25–28, 2005 and again on January 17–19, 2006. This report reflects the views and recommendations of the audit team regarding the readiness of the HQ-T to meet its responsibilities as a reliability coordinator (RC), balancing authority (BA), and transmission operator (TOP).

Audit Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Gerry Adamski*</td>
<td>NERC</td>
</tr>
<tr>
<td>Robert Berglund</td>
<td>East Central Area Reliability Coordination Agreement (now ReliabilityFirst)</td>
</tr>
<tr>
<td>Carl Bridenbaugh</td>
<td>FirstEnergy Corporation</td>
</tr>
<tr>
<td>Kathleen Goodman</td>
<td>Independent System Operator (ISO) New England</td>
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<tr>
<td>Jack Kerr</td>
<td>Dominion</td>
</tr>
<tr>
<td>Donald LaDue</td>
<td>Pacific Gas and Electric</td>
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<td>Quoc Le*</td>
<td>Northeast Power Coordinating Council (NPCC)</td>
</tr>
<tr>
<td>Paul Paquin**</td>
<td>Régie de l’énergie Québec</td>
</tr>
<tr>
<td>Jacqueline Power</td>
<td>NERC</td>
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<tr>
<td>Monique Rouleau**</td>
<td>Régie de l’énergie Québec</td>
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*Team co-leader
**Observer
Organization Profile

Formed in 1944, Hydro-Québec is a provincial Crown corporation in the Canadian province of Québec. The Québec government is its sole shareholder. Hydro-Québec operates six autonomous divisions, each with its own management committee and chief executive officer. The Régie de l’énergie is the provincial regulatory agency that oversees HQ-T and Hydro-Québec Distribution divisions. HQ-T is responsible for the operation of the transmission system.

The Québec power system consists of 20,000 miles of transmission lines, with over 7,000 miles at the 735/765 kV level. HQ-T also operates 506 substations ranging from 44 kV to 765 kV, with 406 of these substations at or above 120 kV. Hydro-Québec has generation capacity of over 39,000 MW including both Hydro-Québec-owned units and contractual capacity commitments such as that with Churchill Falls Labrador Corporation for 5,200 MW. Capacity is provided at 96 percent through hydroelectric plants, primarily in the northern part of Québec’s expansive footprint. Hydro-Québec Production is the autonomous division responsible for Hydro-Québec’s owned generation capacity. Great distance separates the generating resources in the north from the load centers in the central and southern portion of the territory. This configuration results in stability concerns which primarily limit the system. Due to the climatic extremes, HQ-T’s winter peak is 50 percent higher than its summer peak. HQ-T reached an all-time peak of 36,268 MW during the winter of 2003/2004.

HQ-T is asynchronously connected to the remainder of the Eastern Interconnection. HQ-T has 15 interconnections; five are DC ties, and the rest are AC ties to local, isolated pockets of load or generation. HQ-T shares two ties with New York operated in coordination with New York’s Independent System Operator (NYISO), three each with the Maritimes and New England operated in coordination with the New Brunswick System Operator (NBSO) and Independent System Operator New England (ISO-NE), respectively, and seven with Ontario operated in coordination with the Independent Electricity System Operator’s (IESO).

HQ-T operates within the Northeast Power Coordinating Council (NPCC) region and is registered with NERC as a reliability coordinator, transmission operator, balancing area, planning authority, and transmission planner. HQ-T directs the reliability functions of the bulk power system from the System Control Center, identified as CCR from its French acronym. HQ-T implements these directives and operates the local transmission system from seven territorial satellite (Telecontrol) centers.

Following the 1996 approval of the open wholesale electricity market by the province of Québec, HQ-T developed an open access transmission tariff that was initially approved by the provincial government, is currently under the purview of the Régie de l’énergie Québec, and is acknowledged by FERC. HQ-T issued its standards of conduct and implemented its open access same-time transmission system in concert with its tariff filing. HQ-T serves its native load customers in Hydro-Québec Distribution as well as 27 point-to-point customers.
Executive Summary
The audit team found no significant operational problems and concluded that the HQ-T as reliability coordinator, balancing authority, and transmission operator has excellent tools and facilities, well-defined processes, thorough documentation, and competent personnel to perform its reliability functions. HQ-T has committed significant resources to support its operations. However, there are opportunities for its operators to increase participation in HQ-T’s robust training program. The audit team identified a significant number of positive observations and potential examples of excellence. It also offers 17 recommendations that, if implemented, will enhance HQ-T’s reliability readiness. The findings are listed in order of importance.

Potential Examples of Excellence
The audit team identified the following potential examples of excellence in its reliability readiness audit:

1. LIMSEL is an excellent tool to keep operators updated on the system’s current stability limits. (Section 11)
2. HQ-T’s operator-initiated fast-acting load shedding system is intuitive and easy to implement. (Section 11)
3. HQ-T has committed significant resources to its CCR system operators’ training program. (Section 6)
4. HQ-T’s initial training program is well-structured, provides a clear framework to achieve the increased levels of competency and provides frequent feedback to the trainee. (Section 6)
5. HQ-T uses an operator “coach” to guide the trainee throughout the training period. (Section 6)
6. HQ-T reviews and updates the system restoration strategy daily to factor in equipment outages. (Section 13)
7. HQ-T has developed interactive, computer-based simulation training exercises for system restoration, voltage control, automatic generation control (AGC), and system response to contingency events. (Section 6)
8. HQ-T uses special protection schemes (SPS) and load shedding mechanisms to protect its system from extreme events. (Section 8)
9. CCR system operators have extensive and detailed energy management system (EMS) displays for each special protection scheme HQ-T employs. (Section 12.j)
10. The GEODIFFUSION application provides cogent weather and environmental data on an interactive geographical display to enhance the system operator’s awareness of conditions that could impact operations. (Section 11)
11. HQ-T disperses operating reserves across many units to meet its stability reserve requirement. (Section 12.i)
12. This potential example of excellence is related to critical infrastructure and discussed in Appendix 1.

Positive Observations
The audit team noted the following positive observations during the reliability readiness audit process:

1. HQ-T employs five different load shedding methods to maintain system reliability and security. (Section 11)
2. HQ-T’s operating documentation is thorough and well-structured. (Section 7)
3. HQ-T utilizes a structured document development, management, and review process that keeps its procedures current. (Section 7)
4. CCR system operators have a countdown clock on their mapboard to reinforce the urgency of mitigating violations on their system. (Section 12.f)
5. The HQ-T backup control center is completely independent of the primary center and has nearly equivalent functionality. (Section 10)
6. The HQ-T backup control center test procedures include live operation of the system. (Section 10)
7. HQ-T’s planning and operations organizations closely coordinate to maintain system operators’ awareness of system conditions. (Section 8)
8. EMS displays with real-time status and data guide the CCR system operators in the system restoration process. (Section 13)
9. HQ-T has detailed operating procedures to test power supplies at substations and telecommunications facilities that are critical during a blackout. (Section 13)
10. The training technical adviser and the operations manager meet annually with each operator to identify continuing training needs. (Section 6)
11. HQ-T maintains an Oracle database of system and equipment information as the central repository for modeling data. (Section 8)
12. CCR system operators visit the backup control center weekly to test its systems and update its documents. (Section 10)
13. HQ-T considers transmission deliverability in its assignment of operating reserves. (Section 12.i)
14. HQ-T has a fully staffed computer and telecommunications support center to monitor its systems on a 24/7 basis. (Sections 12.b and 20.b)
15. Voltage regulating equipment on the auxiliary buses of HQ-T’s nuclear plant provides optimal flexibility in responding to transmission system conditions. (Section 17)

**Recommendations**

The audit team recommends that HQ-T take the following actions to address issues discovered during the audit process:

1. Provide the CCR system operators additional dedicated time to take advantage of the robust training program available. (Section 6)
2. Implement a plan to address the ongoing training needs of each system operator identified in the annual meeting with the technical adviser and the operations manager. (Section 6)
3. Provide training to each system operator using the computer-based simulation exercises, and provide training for each system operator on the newer special protection schemes and in operating the system live from the backup center. (Sections 6, 10, and 12.j)
4. Evaluate the training curriculum for emergency procedures and develop joint drills with the Telecontrol and generating plant operators to practice the required coordination. (Section 6)
5. Complete the planned upgrade to the next generation of LASER contingency analysis. (Section 11)

6. Provide basic transmission training for the balancing operators to backup the transmission operator while on-shift. (Section 3)

7. Complete the installation of contingency analysis capability at the backup control center. (Section 10)

8. Provide state estimation and contingency analysis capability for the Telecontrol operators to increase their situation awareness of expected conditions following network transmission contingencies. (Section 8)

9. Consider development of an internal operator-qualification program for Telecontrol dispatchers and operators. (Section 5)

10. Review the emergency training curriculum to ensure it is consistent with NERC requirements. (Section 6)

11. Directly alarm the CCR operators of an operating failure of critical EMS applications. (Section 12.b)

12. Implement a mechanism external to the EMS to monitor the alarm processor. (Section 12.b)

13. Implement a preparatory training program for advanced system operator competencies before an operator vacancy occurs. (Section 6)

14. Consider performing a risk-reward analysis for obtaining a traditional HQ-T system-based training simulator to enhance the training program. (Section 6)

15. Include the communications expected between reliability coordinators in the common operating instructions that address HQ-T’s interconnection facilities, particularly for ties with NYISO and ISO-NE. (Section 1)

16. Consider sending all system operators to the NPCC training seminars periodically. (Section 6)

17. Provide standards of conduct refresher training to all CCR and Telecontrol operators at regular intervals. (Section 2)

Discussion
The readiness audit team examined the following key areas during the audit. The detailed discussion that follows provides the foundation for the positive observations, recommendations, and potential examples of excellence that the team identified. The report uses the generic term system operator to refer to all on-shift operating personnel responsible for executing reliability functions. This term will be used for the discussions referring to the operators at the CCR responsible for the bulk power system. When referring to the operators at the satellite centers, the term Telecontrol operator is used.

1. Agreements
The balancing authority must have agreements that establish its authority as a balancing authority. The balancing authority/transmission operator must have agreements that establish the reliability coordinator for its footprint.

Reliability coordinator operators must have plans and agreements in place that establish their authority to immediately direct reliability entities within their reliability coordinator areas to
redispatch generation, reconfigure transmission, or reduce load to mitigate critical conditions and return the system to a reliable state.

HQ-T is a full member of NPCC as evidenced in the Northeast Power Coordinating Council Membership Agreement. Consistent with NPCC requirements, in 2003, HQ-T completed a Québec Control Area Certification Reporting Form, demonstrating that it met the basic requirements to function as a balancing authority. HQ-T is also acknowledged as the reliability coordinator for its footprint by inclusion in the Northeast Power Coordinating Council Regional Reliability Plan dated August, 2005.

HQ-T has developed interconnection agreements for its 15 tie facilities and its point-to-point customer interconnections. In addition, HQ-T has developed thorough common operating instructions that detail the operational coordination with neighboring systems for the tie facilities. HQ-T has also issued instructions for outage coordination and communications with IESO and for general coordination of interconnection facilities.

With the exception of the agreements with NBSO and IESO, HQ-T’s instructions are formalized with interconnection facility operators and not with their reliability coordinators. This arrangement is not an issue for the interconnections with the IESO and NBSO, who function as both reliability coordinator and transmission operator. But for the ties within the ISO-NE and NYISO reliability coordinator footprint, HQ-T instructions are coordinated with Niagara Mohawk and Vermont Electric, for example, without mention of the communications needed at the reliability coordinator level. The audit team recommends that HQ-T include the communications expected between HQ-T and ISO-NE and NYISO at the reliability coordinator level in its common operating instructions.

HQ-T has also developed a formalized agreement with Hydro-Québec Production that addresses ancillary services, operating reserves, outage scheduling requirements, control and monitoring of units 50 MW and higher, and active and reactive capability of the units.

HQ-T has developed an impressive body of facility interconnection guidelines. These documents are easily located on its Web site and address the requirements for generators, transmission customers, and end-user facilities to connect with the HQ-T system.

HQ-T reliability functions are directed by the CCR system operators and executed by the Telecontrol operators. Its well-developed procedures clearly delineate the roles and responsibilities of each participant in performing its reliability functions.

2. Standards of Conduct/Independence

The reliability coordinator must have standards of conduct to ensure that it acts in the interest of reliability for the overall reliability coordinator area and its Interconnection, and not act in a manner that favors one market participant over another.

The reliability coordinator shall act in the interests of reliability for the overall reliability coordinator area and its Interconnection, before the interests of any other entity.
HQ-T’s transmission function is physically and organizationally distinct from the merchant and generation functions located in Hydro-Québec Production. HQ-T has developed and published a standard of conduct that reinforces the concepts found within the NERC Reliability Coordinator Standards of Conduct that HQ-T executed in 2000. HQ-T’s standard of conduct document was approved by the Quebec regulator, Régie de l’énergie.

The CCR and Telecontrol operating staff were trained on these standards of conduct initially but have not had refresher training. HQ-T plans to shorten the refresher training cycle from five to three years for CCR personnel. Telecontrol personnel were not aware of any plans for refresher training. The audit team recommends that all HQ-T operating personnel receive standards of conduct refresher training at regular intervals.

The audit team was satisfied that HQ-T’s operators run the system without bias to market operations, a point confirmed by its neighbors’ responses to the pre-audit questionnaires. HQ-T’s operating procedures for maintaining operating reserves and providing loading relief on interconnections explicitly state the expected operator actions to be implemented and reflect no bias except toward reliability.

3. Operator Authority

The reliability coordinator/balancing authority/transmission operator is responsible for establishing and authorizing the reliability coordinator/balancing authority/transmission operator position that will have the on-shift responsibility for the safe and reliable operation of its portion of the bulk power system in cooperation with neighboring operating entities and the reliability coordinator.

HQ-T divides its transmission system operating responsibilities between the CCR within the System Control organization and seven satellite centers within the Telecontrol organization. The CCR system operators monitor and direct the operation of the bulk power system. The Telecontrol operators direct the operation of the local transmission system and implement CCR directives for the bulk power system operation. HQ-T distinguishes between the bulk power system and the local transmission system based on an established technical evaluation using NPCC’s definition for the bulk power system. A draft NPCC process, Document A-10, has been developed to ensure consistency across the NPCC. The ultimate determination for a particular piece of equipment is based on the impact to the grid of various contingencies.

The roles, responsibilities, and authority for the CCR system operators are clear. For the bulk power system, three system operators manage the reliability functions. The balancing operator controls frequency and operating reserves. The interchange operator manages the interconnection facilities, including transaction management and approval, voltage and reactive control at the interface, switching, and establishing power flow levels on the tie facilities. The transmission operator manages the remainder of the internal HQ-T bulk power system including voltage profiles, power flows, and outage approval. The transmission operator also serves as the shift supervisor with ultimate decision authority. Neither the interchange operator nor the balancing operator, however, is trained to perform the transmission operator functions. Although all operators are NERC-certified at the reliability level, the audit team still questions whether CCR has sufficient operator coverage when the transmission operator leaves the room. The audit team recommends that HQ-T provide basic training to the balancing and interchange operators to back up the transmission operator.
At the Telecontrol centers, the dispatchers and operators perform the reliability functions. The dispatcher holds the senior position in the control center, and the operator performs the actual tasks. For the bulk power system, CCR system operators determine the strategy and coordinate with neighboring reliability coordinators and large industrial transmission customers such as Alcan and Brascan (now Brookfield) as necessary. Once coordination is established, the CCR system operator contacts the Telecontrol dispatcher. The dispatcher instructs the Telecontrol operator and the Telecontrol operator contacts the affected neighbor as necessary and executes the instruction. If needed, tactical details are discussed directly between the CCR system operator and the Telecontrol operator. For the local transmission system, which includes significant portions of network 120 and 230 kV lines, the Telecontrol dispatchers and operators direct and implement all activities.

HQ-T clearly documents the specific expectations of each control center operator in executing his or her reliability functions in its operating procedures, especially in its common operating instructions. Common operating instructions are developed by System Control personnel but its scope includes other HQ-T organizations, such as Telecontrol. The director of System Control, directly reporting to HQ-T’s president, signs each operating procedure, granting sufficient authority to implement the required actions.

Both the CCR system operators and the Telecontrol dispatchers and operators clearly understood the lines of authority and were confident that they could exercise their authority without fear of disciplinary response. HQ-T does not have a specific statement of authority posted in the control rooms nor do the operator job descriptions specifically refer to the obligation to shed load to maintain reliability. However, through its prescriptive operating procedures, the operators’ acknowledgment of their roles, and the operators’ confidence in their authority, HQ-T demonstrated that an operator’s authority to act to maintain system reliability is well-documented and understood.

4. Delegation of Authority

*Any functions that have been delegated must be clearly documented. The documentation must recognize that the reliability coordinator/balancing authority/transmission operator that is delegating the function continues to be responsible for that function.*

HQ-T does not delegate any reliability functions. Organizationally, CCR and Telecontrol are within HQ-T. In its current structure and through its definition of the bulk power system, the Telecontrol satellite center operators run the local transmission system independently from CCR direction provided there is no impact to the bulk power system. CCR system operators direct Telecontrol operators on the operation of the bulk power system. Under CCR direction, Telecontrol operators perform switching on bulk electric elements, manage voltage profiles, and implement emergency procedures such as load shedding and the capacity and energy emergency plan. In case of a system blackout, Telecontrol operators independently implement HQ-T’s black start procedures as part of the system restoration plan prepared by the system control operating procedures team. To help Telecontrol operators distinguish bulk elements from local transmission elements, bulk electric devices are displayed in a different color than local devices on their EMS. Since CCR and Telecontrol are under HQ-T, no formal delegation is required. However, HQ-T’s operating procedures make the roles and responsibilities of each control center and operator explicit and
Telecontrol dispatchers and operators cannot operate any element of the bulk power system without CCR system operators’ authorization.

5. Staff Certification

Reliability coordinator/balancing authority/transmission operators must be NERC-certified operators. The reliability coordinator/balancing authority/transmission operator must have sufficient NERC-certified operator staff for continuous coverage of the reliability coordinator/balancing authority/transmission operator positions.

All CCR system operators are required to be NERC-certified at the reliability level. All HQ-T operators are appropriately certified except one, who was scheduled to take the re-certification examination before his current certificate expires. Because Telecontrol operators do not direct the operation of the bulk power system, HQ-T determined that its Telecontrol operators are not required to be NERC-certified. HQ-T does not have an internal operator qualification program for its Telecontrol operators. Considering that HQ-T relies heavily on the Telecontrol dispatchers and operators to implement its directives, CCR system operators need to be confident that each of them has the knowledge and ability to perform appropriately. Accordingly, the audit team recommends that HQ-T consider developing an internal HQ-T operator qualification program for its Telecontrol operators to establish a consistent baseline of skills and knowledge.

No other HQ-T personnel require NERC-certification and none have an active certification.

6. Training

The reliability coordinator/balancing authority/transmission operators must be adequately and effectively trained to perform their roles and responsibilities. The reliability coordinator/balancing authority/transmission operator must have documents that outline the training plans for the operators. The reliability coordinator/balancing authority/transmission operator must have training records and individual staff training records available for review.

HQ-T has a well-documented and structured training program for its CCR system operators and has committed the resources necessary to continue its evolution. HQ-T received NERC accreditation as a continuing education provider in 2004 and is developing its coursework accordingly. HQ-T’s program includes several potential examples of excellence.

HQ-T’s training staff consists of four technical advisers, four support engineers, and two administrative personnel with assistance from a former technical adviser now located in the human resources organization. HQ-T maintains a technical adviser for each position (transmission, interchange, and balancing) and one for the control room in general. Periodically, these advisers rotate on shift for a week to support the operators and maintain their skills, working 12-hour shifts Monday through Friday and then remaining on-call the remainder of the week. HQ-T has clearly committed significant resources to its training program. The audit team commends HQ-T for its support and notes its commitment of training personnel as a potential example of excellence.

The structure of HQ-T’s training program for new system operators also qualifies as a potential example of excellence. Five years ago, HQ-T implemented a learning management system for CCR operators followed by a similar program for Telecontrol operators. HQ-T hired a consultant to
perform a job-task analysis for each operating position in the CCR control room. From this analysis, HQ-T developed a “know-how” list of activities for each position. For each activity, HQ-T created a technical skills profile, the observable performance criteria, tools and references available, and the prerequisite skills and knowledge. From this foundation, HQ-T developed a computer-guided skills assessment to identify training needs and develop a strategy for each individual. Inadequate skills, rated as one or two on a scale of four, are flagged. Skills are assessed periodically throughout a trainee’s program to highlight additional training areas and adjust the personal strategy as necessary.

HQ-T’s development framework includes the following programs: welcome and integration, theoretical training, specialized theoretical training, coach-assisted training, English-speaking training, and on-the-job training. HQ-T designated four of its operators to be formally trained as coaches. The coach serves as mentor to the trainee, monitors the trainee’s progress, observes the trainee on the job, and takes time out of the shift rotation to work with the trainee on individual needs. Each coach attends a two-day training session. The audit team identified HQ-T’s use of coaches to be another potential example of excellence. A trainee is deemed ready to operate independently upon successful completion of the competency checklist and with approval from the coach and the operations manager. One HQ-T system operator commented that this program was the best training program he had ever seen.

The interchange operator is the entry position in the CCR, with progression to the balancing position, and ultimately the transmission operator. System operator candidates for the interchange position are drawn from the dispatcher positions at the Telecontrol satellite centers. HQ-T estimates that training for the balancing and interchange position requires six months and that training for a transmission operator requires 11 months. Operators must provide three months notice if they intend to retire or resign. HQ-T has not developed a program to prepare an interchange operator to perform balancing functions prior to a vacancy occurring. The audit team recommends that HQ-T develop a preparatory training program for advanced system operator competencies and implement it before a vacancy occurs thereby reducing the training time needed for the new position.

HQ-T’s approach to continuing operator education is less robust than its initial training program. HQ-T recently acquired a computer-based module entitled The Personal Development Plan to structure the continuing system operator education plans. Based on individual needs, task-related technical skills, and management input, an annual development plan will be developed for each system operator. Currently, the operations manager and the training technical adviser meet with each operator annually to identify continuing training needs, an activity the audit team views positively. But these identified needs have not resulted in a structured and actionable training plan for the system operator. The audit team views the new administrative tool as a step toward the needed structure. The audit team recommends that HQ-T continue with the annual conferences and implement plans to address the training needs identified.

HQ-T maintains its training program on an interactive intranet Web application. The audit team was impressed with the application, which makes the entire training program, including skills assessment evaluations, courses, personalized development plans, and related information, available to each system operator and trainee at all times.
HQ-T’s training curriculum is very thorough. HQ-T’s engineers, management, support staff, and, in some cases, consultants deliver the training to the system operators. HQ-T’s system operator training modes include self-guided computer training, instructor-led training, and regional seminars. Of particular note as a potential example of excellence, HQ-T has developed interactive computer-based training simulation exercises for HQ-T-system-specific restoration, voltage control, AGC, and system behavior under contingency conditions, and is developing a capacity deficiency module. The voltage simulator uses a state-estimated case as its starting point, providing a foundation using actual system conditions. Although not a simulator in the traditional sense, these modules provide immediate technical feedback to the system operators for their chosen actions and offer a tremendous learning opportunity. Since these simulations are newly developed, all CCR system operators have not trained on them yet. The audit team recommends that HQ-T require its system operators to take part in this training.

HQ-T does not have a traditional training simulator with a detailed representation of its system. The audit team recommends that HQ-T consider performing a risk-reward analysis for a traditional training simulator to further enhance the program.

CCR system operators used to attend the bi-annual NPCC training seminars but have not done so recently. The audit team recommends that HQ-T review this decision and consider sending its CCR system operators to the NPCC regional training seminars.

CCR system operator schedules provide a dedicated relief shift for coverage and training. According to the system operator training records for 2004 and 2005, the system operators received required emergency training, but not much else. The CCR system operators further questioned whether the emergency training provided meets NERC’s standard requirement. With the robustness of the program and the resources committed to it, the audit team sees an opportunity for improvement. The audit team recommends that HQ-T allow its system operators additional time to utilize the training program and to ensure its emergency training curriculum is consistent with NERC Reliability Standards.

The audit team did not review the Telecontrol operators’ training program in detail. Telecontrol maintains a separate training staff and program and does not coordinate it with CCR. Since Telecontrol operators implement the directives of CCR system operators, especially for emergency procedures such as system restoration, control center evacuation, and the capacity and energy emergency plan, the audit team felt that joint drills or exercises between CCR and Telecontrol operators would be beneficial. Telecontrol operators are included in control center evacuation exercises and the capacity and energy emergency plan training, and plan coordinators present the system restoration plan annually to Telecontrol dispatchers and operators. The audit team recommends that HQ-T evaluate the training exercises and drills for its emergency procedures and, if beneficial, develop joint drills that emphasize the coordination between CCR and Telecontrol operators.

7. Operating Policies and Operating Procedures

The reliability coordinator/balancing authority/transmission operator must have an established procedure to ensure that reliability coordinator/balancing authority/transmission operators and
operations staff are aware of any changes to NERC, regional, and/or local policies or procedures prior to taking over control of a shift position.

The reliability coordinator/balancing authority/transmission operator must have shift change procedures for updating incoming shift personnel on the current status of the system.

HQ-T’s documentation thoroughly covers the procedures needed to operate a reliable system. The audit team viewed the quality and structure of HQ-T’s documentation as a positive observation. HQ-T has a 9 person group in the System Control organization that develops and administers its 160 operating procedures.

HQ-T categorizes its documents as follows: directives (D), instructions (I), references (R), emergency (U), common (C), and standards (N). Procedures which extend beyond System Control, such as those involving Telecontrol operators, are labeled “GEN” for general. For example, GEN-C-001 is a common operating instruction for an interconnection facility. If a Telecontrol center determines that a procedure requires modification, its staff updates the procedure and forwards it to the HQ-T procedures group to ensure consistency.

HQ-T has a structured document management and control process that the audit team viewed as positive observation. HQ-T details the document management and/or revision process in a flowchart. Effected parties, including system operators, provide input before a procedure is finalized. All procedures are signed by the director of System Control, who provides the executive authority to implement the actions specified in the document. The revision process can be triggered by an operator request, the commissioning of a new automatic device or special protection scheme, the installation of a new facility, a change in standards, a change in operating strategy, or the mandatory review cycle. Each document is assigned a review cycle between six months and three years.

Each CCR operating position has an electronic bulletin board, and a technical advisor advises operators daily of new strategies, procedures, and policies. System operators are kept informed as follows: for information of lesser importance, HQ-T issues a memorandum; for items of increasing importance, a computer-based training exercise is developed, and for matters of high importance, a classroom-based training session is held. At the beginning of each month, a list of all revised operating procedures is provided to the control room and operations support managers who then forward it to their system operators and staff. The operational procedures group is currently developing an on-line questionnaire for selected procedures to provide immediate validation of operator understanding.

There is no formal shift turnover procedure. System operator schedules overlap by twenty minutes. Each position has an official log and a daily report (green sheets) that contains information that does not belong in the official log, such as personnel issues and reminders.

8. Planning

The balancing authority/transmission operator and its supporting planning organizations must have a process for day-ahead planning, and for longer-term planning, such as week-ahead, seasonal, and
year-ahead, for the operation and outage scheduling of transmission facilities and generation and reactive resources.

The balancing authority/transmission operator and its supporting planning organizations must have agreements with its reliability coordinator to ensure that day-ahead and longer-term plans for the operation and outage scheduling of transmission facilities, and generation and reactive resources, will not jeopardize the reliability of the bulk power system.

The asset planning organization (PdA), which reports directly to HQ-T's president, performs HQ-T’s planning functions. Within this organization, the programs and strategies group performs most of the operational planning studies. They interface with the operating procedures group, the support and integration group, and the system scheduling group and translate the results of the planning studies into useful operator information.

HQ-T’s long-range planning process is based on NPCC’s Document A-02, which provides the criteria for the design and operation of the interconnected power system. To ensure that HQ-T’s transmission expansion plan complies with the criteria, NPCC requires an area transmission review, guided by its Document B-04. NPCC requires an exhaustive review at least every five years with annual interim updates. PdA performed its last detailed review in 2002 and has submitted updates annually since then. Each review covers a four- to six-year time frame.

In its area review, HQ-T details the criteria it uses to identify bulk power system elements. The report shows the results of detailed steady state and dynamic stability studies for normal, single, and multiple contingency outages and extreme contingency conditions, which address NERC Reliability Standards TPL-001 through TPL-004 Transmission Planning Table I Transmission System Standards requirements. HQ-T exceeds NERC’s reliability standards by viewing a breaker failure as part of a single (normal) contingency. HQ-T uses the ElectroMagnetic Transients Program (EMTP) and Mathlab for its transient stability analysis and Power System Simulator for Engineering for steady state analysis. HQ-T’s voltage stability program, entitled ASTRE, performs dynamic simulations in the zero to 10 minute time frame for normal or extreme contingencies. ASTRE’s time domain accounts for the response of generators, loads, transformers, static var compensators, and special protection systems.

The impacts of events in this analysis are limited to the HQ-T footprint as the system is asynchronously connected. To address these impacts, HQ-T employs a shunt reactor switching system, underfrequency load shedding, undervoltage load shedding, generation rejection schemes, and remote load shedding to preserve the integrity of the grid. With these schemes, HQ-T limits the amount of expected load loss and generation rejection to 3,500 and 5,000 MW respectively for extreme contingencies. The audit team noted HQ-T’s use of special protection systems and load shedding schemes for extreme events as an example of excellence.

To determine resource adequacy, Hydro-Quebec Distribution performs an overall load forecast for future years. Based on these forecasts, HQ-Distribution, in its LSE function, assesses the need for additional generation or capacity resources to meet the load increase and maintain the required reserve margin in the study time frame. HQ-T PdA determines the need for additional transmission to assure that transmission capacity will meet the load and resource delivery requirements. Through
its heritage pool agreement, Hydro-Quebec Distribution is obligated to purchase power from Hydro-
Quebec Production up to a certain level, above which it can select another supplier. To meet future
capacity requirements, Hydro-Quebec Distribution calls for tenders to any power producer to meet
its resource requirements and decides on the most attractive proposal. HQ-T PdA develops the plans
for transmission additions or upgrades based on this decision process and synchronizes the steps to
implement the new transmission facilities in the required time frame. These long-term plans are
incorporated into HQ-T’s area transmission review and HQ-D’s resource adequacy assessments,
which are also elements of the NERC/NPCC compliance program.

HQ-T’s planning and operations support groups work closely together, another point noted by the
audit team as a positive observation. PdA performs exhaustive system analyses to identify system
limits under expected normal and contingency conditions for the upcoming season and in real time.
The operations support group enters this limit information into the limit selection (LIMSEL)
software, the key program that CCR operators use to determine system stability limits based on real-
time conditions. CCR operators also use the real-time contingency analysis program LASER to
assess thermal system performance. For operational measures beyond generation re-dispatch and
transaction curtailments, PdA develops detailed operating procedures for each concern in
conjunction with the operating procedures group. Each month, operations and planning support staff
train the system operators on expected upcoming operating conditions and the associated mitigation
procedures.

HQ-T’s system scheduling unit manages the transmission and generation outage plan. For each
week of the year, HQ-T develops a forecasted peak load, an operating reserve requirement with an
uncertainty factor, and a generation dispatch and transaction scenario. They then factor in planned
outages and compare expected system operating conditions with pre-determined transmission limits
to determine if the outages can be tentatively approved. If studies have not been previously
performed for the expected system configuration, PdA performs the study to determine appropriate
stability limits. A more detailed review is conducted four weeks before the outage and when needed,
a load flow analysis is performed to assess thermal capacity. For the day-ahead plan, HQ-T
performs an hourly assessment, including day-ahead transactions, before the plan is finalized.

HQ-T maintains an Oracle database with current information on all equipment on the Québec grid,
including factory tests, field tests, and name plate information. The audit team noted this central
equipment database, used by both operations and planning, as a positive observation. HQ-T
provides its system modeling information per NPCC Document C-29. Hydro-Québec’s Distribution
division provides the updated load forecast for steady state models, and HQ-T uses load composition
analysis from its LOADSYN application for its dynamic load models. Generator dispatch data is not
required for long-term studies since the most significant system stress is caused by all generators
operating at maximum output, due to the geographical separation of source and load. Generator
dynamic control models are based on field testing performed when generators were commissioned
and have not been validated since. Real power testing is performed annually to validate maximum
output, and HQ-T has just initiated a reactive capability testing program for all units 50 MW and
higher. The audit team encourages HQ-T to continue this program and to work with wind generators
to develop accurate unit modeling information. Any new data should be incorporated in HQ-T’s
real-time and off-line models. PdA is responsible for maintaining current, accurate system models
and periodically validates its Oracle database representation against the on-line state estimator. PdA
captures five-minute state-estimated system snapshots following significant events that it then simulates off-line and compares against disturbance fault recording information from the event.

The Telecontrol organization has its own independent strategies and analysis group to support the operation of the local transmission system. Telecontrol does not have real-time contingency analysis tools although it does operate network transmission. Off-line studies determine relevant operating points for expected conditions. The audit team recommends that Telecontrol provide real-time contingency analysis capability to increase its operators’ situational awareness of system response to contingencies.

9. Outage Coordination and Communication

Planned transmission facilities and generating unit outages must be coordinated with the reliability coordinator to ensure that conflicting outages do not jeopardize the reliability of the bulk power system.

Information relative to forced outages of transmission facilities and generating units that may jeopardize the reliability of the bulk power system must be shared with affected balancing authorities, transmission operators, and the reliability coordinator as expeditiously as possible.

HQ-T defines equipment outage coordination in its GEN-D-007 document, *Retraits de l’exploitation nécessitant une approbation de CMÉ*, with supporting reference information found in the GEN-R-007 document. The directive clearly outlines the process and time frames for submitting outage requests, and refers to the common operating instructions for coordinating outages on tie facilities with neighbors. HQ-T requires a minimum 10-day notice for outages affecting interconnections. Organizations send outage requests for both bulk and local transmission equipment to the Telecontrol organization, which performs a preliminary assessment before forwarding them to the system scheduling unit (PCME) of System Control if they impact the bulk power system. PCME’s minimum outage request lead times depend upon if the request was previously included in the annual outage plan, the type of equipment affected, whether the facilities are transmission or generation-related, if the dates or duration of a planned outage are changed, or the expected impact on transfer limits or operating reserves. The planned outage request lead times range from three to 30 days. PCME outage schedulers analyze the outage requests and approve or deny them as appropriate, exercising authority provided in procedures such as 33199-D-001 regarding operating reserves maintenance.

Each fall, HQ-T develops an outage plan for the upcoming year. For each week of the year, PCME personnel use load forecasts, interchange schedules, and generator outage schedules to determine transmission limits, balancing needs, and other reliability concerns at a higher level. The integrated plan is updated weekly throughout the year as conditions change. PCME personnel then analyze the expected system conditions in greater detail one month in advance. Following the receipt of outage requests, PCME performs detailed analyses in the operational planning time frame and again the day ahead of the outage. Finally, the outage schedulers publish a list of the hourly operating limits for the next day.

System operators also review the outages prior to authorizing Telecontrol operators to perform switching. They use LIMSEL in study mode to assist in this analysis.
10. Plans for the Loss of Control Facilities

The reliability coordinator/balancing authority/transmission operator must have a workable plan to continue to perform the reliability coordinator/balancing authority/transmission operator functions that are required to maintain a reliable bulk power system following the sudden catastrophic loss of its primary control facility, or the partial or full failure of its computer facilities or monitoring tools at the primary control facility.

HQ-T has a thorough set of operating procedures and plans for response to the loss of the CCR and its facilities and systems. These procedures comprehensively detail the roles and responsibilities of the individuals involved in the processes. The following documents comprise these response plans:

1. GEN-D-089 — System Control Center or Forecasting Function Outages: contains response procedures for outages of computer systems, partial or total loss of the control center, evacuation of the control center, use of Telecontrol center personnel, and returning to normal activities; and procedures for the system scheduling unit for the loss of its systems or the evacuation of the entire complex.
2. 33199-I-089 — Control Center Evacuation — Transfer Procedure to backup control center.
5. Plan d’urgence CMÉ — HQ-T’s system control emergency plan, which supports the operators during crisis situations and installs a conduit for communications about the event.
6. Verification de SPECTRUM au RCCR REV-2002-10-03 — procedures for HQ-T’s EMS computer support personnel to verify that the EMS at the backup center is functioning properly.
7. Emergency Preparedness Exercise Schedule — contains the list of exercises for system restoration, the system control emergency plan, and control center evacuation in 2005.
8. System Control Operating Document Index — documents available to the operators at the backup site.
9. 33199-D-050 — System Control Emergency Center — replication of Plan d’urgence CMÉ directed specifically to CCR system operators.
11. 33199-D-055 — Loss of Communications with a Satellite Control Center.

For EMS problems that do not require evacuation, CCR system operators inform Telecontrol operators who monitor the system while the problem is being addressed. If the control center needs to be evacuated or if the EMS problem exceeds 30 minutes, the backup facility plan is implemented and CCR system operators transition to the backup center. During the transition, CCR system operators transfer supervision to designated Telecontrol centers, one for balancing functions and one for voltage control. CCR operators then assign communications with neighboring reliability coordinators to the appropriate Telecontrol centers after notifying the reliability coordinators of the problem. This interim phase lasts until CCR system operators resume control at the backup center, expected to be no more than 45 minutes to an hour. CCR system operators are expected to take with them the suitcase containing any new procedures or guidelines and computer databases that were
issued or updated since their last visit. CCR system operators remain responsible for their reliability functions during the transition and maintain their authority through mobile communications.

CCR’s backup control facility is 30 minutes from the primary center. It is completely independent and has the same functionality as the CCR except for LASER. The backup center has three full system operator positions and office space to support HQ-T’s technical staff for the long-term. The audit team notes HQ-T’s backup center approach as a positive observation but recommends that HQ-T complete its plan to implement LASER or its successor at the backup control center.

HQ-T conducts training sessions two to three times per year to keep CCR operators familiar with the backup center and its plans. HQ-T also conducts an annual evacuation and training exercise in which operations are fully transferred and the system is operated live from the backup center. Telecontrol operators participate in the evacuation stage of this drill as control is temporarily transferred to them during CCR system operator transition. The audit team noted the use of the backup center to operate a live system during the drill as a positive observation. When the backup site is made operational, CCR system operators have full use of the EMS and its applications, LIMSEL, and the remote load shedding systems. Since these exercises are relatively new to the curriculum, not all CCR system operators have yet participated in them. The audit team recommends that HQ-T provide each CCR system operator with hands-on experience operating the system live from the backup control center.

CCR system operators visit the backup control center weekly or as schedules allow to verify operability of the computer and communications systems and to update documents. The audit team notes this practice as a positive observation.

11. Tools
The reliability coordinator/balancing authority/transmission operator must have adequate analysis tools such as state estimation, precontingency, and postcontingency analysis capabilities (thermal, stability, and voltage) to perform the reliability coordinator/balancing authority/transmission operator functions.

HQ-T provides an impressive set of tools to support its system operators in executing their reliability functions. HQ-T’s Siemens Spectrum EMS was installed in 2001. HQ-T’s AGC, balancing, and interchange applications are part of the EMS. HQ-T has 20 EMS system operator and support consoles at the primary and backup centers, each with individually assigned authorities.

HQ-T’s state estimator and real-time network analysis application (LASER) are not part of the Siemens EMS package. LASER solves for 500 n-1 contingencies at five-minute intervals, when the system topology changes, or at the system operator’s request. LASER can also operate in study mode. CCR system operators receive an alarm when the state estimator or real-time contingency analysis fails to solve. The LASER application uses antiquated technology and is not user-friendly. HQ-T is already pursuing the next generation, LASER II. The audit team recommends that HQ-T complete this project. LASER II is more user-friendly, presents results in one-line format, allows added modeling capability, and will be available to the operational planning group. The audit team further recommends that HQ-T install the LASER II application at the backup control center and offer state estimation and network analysis capabilities at the Telecontrol centers.
LIMSEL is the primary tool used to operate the Québec area reliably within transmission system stability limits. HQ-T’s planning organization performs an exhaustive dynamic stability security analysis of its critical facilities and the system’s response to loss of additional elements. From these studies, over 300 system stability limit tables are developed with sensitivities based on availability of series-compensation and available reactors. These configuration-specific limit tables are manually loaded into the LIMSEL application. Actual system operating parameters are fed into LIMSEL, and real-time stability limits are identified based on the table developed for specific system conditions. These limits feed into the EMS for alarming and monitoring. When system topology changes, LIMSEL provides a new limit to the EMS within three seconds with an alarm to alert the operators. This tool is an excellent application and was noted as a potential example of excellence. HQ-T is currently automating the table loading process, which will make the application even better.

The audit team noted as a positive observation that HQ-T employs five different methods of load shedding to maintain system security: under frequency load shedding (UFLS), under voltage load shedding, certain special protection schemes (SPS), manual load shedding as implemented by the Telecontrol centers, and fast-acting load shedding. The fast-acting load shedding program in particular was recognized as a potential example of excellence. This program is separate from the EMS and consists of a box that sits on the operator console. Large push buttons on the box provide 10 options for quick-response regional load shedding. After selecting the regions, the operator pushes a green load shed button that opens up lower-voltage transmission circuits, thus shedding load. The application is intuitive and quickly implemented.

The tool named GEODIFFUSION is another potential example of excellence. This tool provides weather and environmental information on an interactive geographic system map that facilitates operational decisions on resource deployment and system configurations. This tool integrates lightning detection data, geomagnetic storm monitoring information, forest fire location data, and ice load monitoring data for individual transmission circuits. The tool also provides alerts and user-selectable data views via overlays and pop-up windows.

HQ-T’s dynamic mapboard at the CCR, fed by data from the EMS, presents an overview of the bulk power system. The data includes voltage, real and reactive power flows, frequency, current time, number of generators synchronized, net real and reactive generating station output, number of static var compensators in service, total reactive static var compensator output, reactor status, transmission line status, and flow indicators as a percentage of facility ratings. The mapboard also shows flashing white indicator lights when communication is lost at a substation. HQ-T employs an EMS display projection system for mapboard capability at the backup center.

CCR system operators also utilize an outage scheduling program, a transaction check-out tool, the Open Access Same-Time Information System, the Open Access Technology International tagging application, a generation scheduling module, a reserve calculator, EMS and internet-based trending tools, and SPS supervision.

HQ-T continually evaluates and implements upgrades to its EMS and operating tools to enhance functionality. HQ-T maintains a 10-year project window for capital budgeting purposes. HQ-T currently has funded projects for LASER II, for a tool that calculates reserves at 15-minute intervals.
for the entire day, and for a tool that updates the load forecast at 20-minute intervals for the day. HQ-T recently completed its EMS upgrade project and is nearing completion of projects to modernize LIMSEL, LASER, and the data archiving and forecasting systems.

12. Real-Time Monitoring

a. System Visibility

*The reliability coordinator/balancing authority/transmission operator must monitor operating data and status in real-time operation for its area and adjacent areas as necessary to maintain situational awareness of its system.*

CCR system operators can view all bulk power system elements, all generating plants greater than 50 MW, the interconnection facilities with Alcan and Brookfield (formerly Brascan), and other elements that impact voltage control. CCR system operators also monitor their neighbors’ equipment up to the interconnection bus. Information beyond the bus is not needed for asynchronous DC ties or local AC ties. CCR system operators maintain situation awareness by viewing this information in the EMS and on the dynamic mapboard. In addition, each operator has customized EMS overview displays that support his or her individual responsibilities. Telecontrol operators can view all bulk and local transmission elements and generating facilities within their defined footprint. The Telecontrol EMS color-codes local transmission elements in gray and bulk power system elements in green.

b. Alarms

*The reliability coordinator/balancing authority/transmission operator must have effective and reliable alarming capability. This should be supported in the energy management system (EMS) and/or supervisory control and data acquisition (SCADA) system by alarm priority.*

The Siemens alarm processing application provides color-coded alarm prioritization, 40 assignable alarm categories, and console-selectable audible alarming. HQ-T divides its alarms into major and minor categories. Minor alarms can be acknowledged and deleted at any time while major alarms can be deleted only when the problem has been resolved. The alarm application also has a system events summary page with many filtering options.

HQ-T’s distinct computer and communications support groups monitor the computer applications and systems and the telecommunications infrastructure. This support, which is provided 24 hours per day, seven days per week from a dedicated room near the CCR control room, is noted as a positive observation. HQ-T does not directly alarm the CCR system operators when some critical applications fail. It relies on the computer support group to recognize a problem and alert the system operators. While this arrangement was acceptable to the system operators, the audit team was concerned that an operator might not notice the state of his or her tools without a timely warning. The audit team recommends that HQ-T directly alarm its system operators when critical applications are not operating properly. Additionally, HQ-T has no mechanism independent of the EMS to monitor the alarm processor itself. Therefore, the audit team recommends that HQ-T develop an external
means to monitor the alarm processor so that system operators can be sure that their alarm tools are functional.

c. Frequency

The reliability coordinator/balancing authority/transmission operator must monitor frequency and direct actions to resolve significant frequency errors, and correct real-time trends that are indicative of potentially developing problems. Frequency monitoring points should be of sufficient number and from several locations with sufficient area coverage to allow the reliability coordinator/balancing authority/transmission operator to effectively monitor the reliability coordinator/balancing authority/transmission operator footprint to determine possible islands.

CCR system operators have seven designated frequency points on their 735 kV system available in the EMS. The EMS also contains a frequency point synchronized to the NYISO and another point from a Telecontrol station in the Montreal region. These points are provided on a single screen. For AGC, there is automatic failover between the multiple frequency sources. A frequency chart meter and/or recorder on the mapboard at the primary and backup control centers is driven from a source independent from the EMS.

Telecontrol operators have other frequency points available including frequency values from each generating plant. The Telecontrol operator interviewed did not immediately know the number of points available. Since Telecontrol operators direct the blackstart process, these additional frequency points are essential.

HQ-T has implemented an automated UFLS program that, coupled with generation rejection schemes, protects the asynchronous system from unacceptable frequency disturbances. HQ-T’s UFLS program exceeds the requirements established by NPCC.

d. Voltage

The reliability coordinator/balancing authority/transmission operator must monitor voltage levels and take appropriate actions to support the bulk power system voltage if real-time trends are indicative of potentially developing problems. Voltage measuring points must be of sufficient number and from several locations and voltage levels to allow the reliability coordinator/balancing authority/transmission operator to effectively monitor the voltage profile of its balancing authority/transmission operator footprint.

CCR system operators control the voltage on the bulk power system by directing the Telecontrol operators to act. Their actions include interfacing with HQ-T’s neighbors and generating plant operators or remotely controlling the plants. Telecontrol operators control the voltage profiles of the local transmission system independent of the CCR system operators unless their actions will impact the bulk power system. In this case, they contact the CCR system operators to discuss the situation and determine an appropriate strategy.

HQ-T does not maintain a load-biased voltage schedule; instead, voltage operating ranges are clearly defined for equipment in each voltage class and the operators keep the system within these limits. For example, HQ-T designates the normal voltage range on its 735 kV system
to be 730 to 750 kV, with an emergency range of 725 to 760 kV. The lower voltage classes operate within a range of 5 percent of nominal voltage.

Generating units do not have a voltage schedule per se, but when they synchronize to the system, they operate to the same unit voltage set point as they did the last time they were synchronized, unless told differently by the Telecontrol operators. If the generator impacts the bulk power system, the CCR operator establishes the voltage set points of the unit. HQ-T has installed power system stabilizers on nearly all units greater than 50 MW and has automatic voltage regulators that operate in automatic voltage control mode. Plant operators are required to inform the Telecontrol operator if one of these systems changes status or if an equipment problem affects its reactive capability. These limitations are noted on de-rating tags.

HQ-T has installed significant reactive resources to control voltage and reactive power levels and to maintain system stability. System operators tend to use switched shunt devices to manage voltages, acknowledging that generator reactive output is of limited use due to its distance from the load. HQ-T has developed operating procedures for the operators to follow under high or low voltage conditions. Steps range from de-energizing circuits in low load periods to shedding load in high load periods. Should voltage exceed the prescribed limits, CCR system operators have 15 minutes to return it to within the normal range. To protect for extreme contingencies, HQ-T has installed an under voltage load shedding scheme that monitors the voltage in five major substations near major load centers and is able to discriminate whether an event is normal or extreme. If an event is extreme, the under voltage load shedding will shed load to prevent overall system voltage collapse.

CCR system operators have multiple voltage tabular displays to monitor the bus voltages on the system against the established limits. For an overall profile, operators use the dynamic mapboard.

e. Reactive Reserve

*The reliability coordinator/balancing authority/transmission operator must ensure that reactive reserves are available and properly located to satisfy the most severe single contingency.*

HQ-T’s robust planning study processes (voltage, angular, transient, etc.) focus on maintaining stability on the Québec system. As a result, HQ-T’s reactive reserve requirements and the availability of reactive resources are factored into the stability limits, which the CCR system operators use for system operation and monitoring. Dynamic support for HQ-T’s system is effectively provided by static var compensators, synchronous condensers, and automatically controlled shunt reactors and condensers. The availability and capacity of these devices are displayed to the CCR system operator and integrated into the LIMSEL software. The CCR system operators have the actual reactive output and the maximum reactive capability for the generating stations, as verified through annual testing and shown on a single display. Since generators are distant from the load centers, they do not effectively provide reactive support; therefore, HQ-T does not explicitly calculate reactive reserve for the units, although the system operators can easily compute it. On this
same display, the actual and maximum capability of condensers is presented for a dozen load areas and/or zones. HQ-T has another display that presents the status of the shunt condensers and reactors also arranged by load zones. With these two displays, the CCR system operators can quickly assess the status of their reactive resources.

HQ-T’s operating directives for voltage control pre-define the operation of reactive devices to maintain local transmission voltage levels. HQ-T coordinates with its neighbors to minimize reactive flow according to the common operating instructions.

f. Critical Facilities

Monitoring of facilities that are critical to the reliability of the bulk power system is a joint responsibility of the balancing authority operators, transmission operators, and reliability coordinators.

There must be an established process to determine which facilities will be considered critical to the reliability of the bulk power system and real-time operating information (data and status). Operating limits for the critical facilities must be provided to the balancing authority, transmission operator, and the reliability coordinator.

The CCR transmission operator is accountable for monitoring critical facilities. All equipment under the purview of the CCR is considered critical since, by definition, an outage to this equipment could affect regional transfer capability or stability per the detailed bulk electric equipment analysis performed seasonally. HQ-T maintains a separate, internal list of key facilities and critical components that impact a system restoration path. For any planned or forced outage to one of these facilities, operations support staff re-defines the specific restoration strategy without the path and issues a memorandum to the operators.

LIMSEL provides real-time stability and transfer limits for monitoring the system. Network topology changes direct LIMSEL to a different limit table based on actual system conditions. LIMSEL displays show the factors contributing to the derivation of limits in a flow chart showing dynamic status and values. CCR operators can use LIMSEL study mode to determine the impact of a planned outage. LASER determines thermal constraints and sends messages and alarms to the EMS when a violation or potential violation is identified.

When an actual event or contingency occurs, a 15-minute countdown clock on the mapboard shows the operator how much time is left to return the system to within limits. The audit team identified the countdown clock as a positive observation.

HQ-T shares planned and forced outage information with adjacent areas and reliability coordinators in real time and in weekly NPCC conference calls. HQ-T’s common operating instructions identify outage coordination information. HQ-T also maintains a list of events it reports on the Reliability Coordinator Information System (RCIS) in procedure GEN-D-011, which also contains an internal notification protocol for many system events.
g. Transmission System Congestion

The transmission operator must monitor transmission flowgates and be prepared to take actions to alleviate congestion in conjunction with, and as directed by, its reliability coordinator.

A reliability coordinator shall take appropriate actions in accordance with established policies, procedures, authority and expectations, to relieve transmission loading.

The CCR interchange operator is accountable for transmission system congestion. The NERC transmission loading relief procedure is utilized only on interconnection facilities since internal congestion is managed through the transfer and stability limits in LIMSEL. When congestion does occur on an interconnection, the interchange operator uses a local loading relief procedure consistent with the NERC transmission loading relief procedure, using tags associated with the interchange schedules on the interconnection facility. The operator notifies the neighboring reliability coordinators and posts the information to the RCIS.

h. Load Generation Balance

The balancing authority operator must monitor the balance of load, generation, and net scheduled interchange in its balancing area. The balancing authority operator must take actions to mitigate unacceptable load, generation, and net scheduled interchange imbalance.

The CCR balancing operator is accountable for HQ-T’s balancing function. Because of HQ-T’s asynchronous connectivity, the system is operated in flat frequency mode. Consequently, balancing operators pay close attention to EMS frequency deviation and associated alarms as their primary indicator of system control. HQ-T’s primary frequency monitoring point is at the Dorchester substation and the first backup is the independent point that drives the frequency meter and/or recorder on the mapboard.

HQ-T, through its AGC system, directly controls over 16,000 MW of generation with the remainder controlled through the Telecontrol operating centers. HQ-T presented records confirming full compliance to the control performance standards over the past 12 months receiving excellent response from the hydroelectric facilities that comprise over 95 percent of the HQ-Production portfolio. HQ-T displays the control performance average for each 10 minutes of the day to increase the operator’s awareness.

Although unrelated to control performance, the audit team noted that HQ-T appeared to have accumulated excessive inadvertent interchange with NYISO. As this is an after-the-fact indicator with no bearing on reliability, the audit team is not offering an official recommendation but encourages HQ-T to investigate the basis for this accumulation.

i. Contingency Reserves

The balancing authority operator must monitor the required reserves and the actual operating reserves in real time, and take action to restore acceptable reserve levels when reserve shortages are identified. If necessary, the reliability coordinator shall direct the balancing authorities in the reliability coordinator area to arrange for assistance from
neighboring balancing authorities. The reliability coordinator shall issue energy emergency alerts, as needed, and at the request of its balancing authorities.

The CCR balancing operator is accountable for maintaining the operating reserves in the Québec area. HQ-T’s operating reserve calculation consists of 100 percent of the largest contingency attainable within 10 minutes (1,000 MW), 50 percent of the second largest contingency attainable within 30 minutes (500 MW), and 1,500 MW additional reserve to account for uncertainty in the day-ahead forecast, reduced to 500 MW in the four-hour look-ahead calculation. Concurrent with these levels, HQ-T maintains 3 percent stability reserve on each synchronized unit. Due to this stability reserve requirement, HQ-T disperses its operating reserves across the entire footprint, an approach noted as a potential example of excellence. Through LIMSEL, HQ-T considers transmission deliverability when identifying operating reserves, a positive observation noted by the audit team. HQ-T does not participate in a reserve sharing group such as the NPCC shared activation of reserves process. However, HQ-T will provide emergency assistance, if able, when a neighbor makes the request.

HQ-T’s EMS has a concise, well-organized tabular display for all types of reserves, including reserve requirements and reserve margins. If the required levels of either class of reserves fall below required levels, the balancing operator receives an alarm and implements remedial actions following operating procedure 33199-D-001. These actions include curtailment of recallable transactions, the use of gas-turbine generation, synchronization of additional hydroelectric units to the system, and load shedding to restore reserves if necessary. Over 90 percent of HQ-T’s operating reserves are under automatic governor control at all times. HQ-T’s EMS calculates its actual reserve levels each minute.

HQ-T was completely compliant with NERC’s disturbance control standard for the previous four quarters.

j. Special Protection Systems

The balancing authority operator, transmission operator, and the reliability coordinator must be aware of the operational condition of special protection systems that may have an effect on the operation of the bulk power system.

HQ-T employs a total of 20 special protection systems (SPS) on the system. HQ-T installed the majority of the SPSs to protect against overloading from local single contingencies. Seven SPSs are specifically designed to maintain system stability, avoid voltage collapse, and mitigate against high frequency or power swing conditions associated with certain single and extreme contingencies. HQ-T identified these contingencies as having significant impact outside of the local area. These schemes use a variety of techniques including generation rejection, capacitor and reactor switching, load shedding, transfer reduction, and transmission line tripping. The CCR transmission operators are responsible for monitoring the status and operating mode of each scheme. CCR system operators have extensive and detailed EMS displays to assist them for each scheme. The audit team noted this presentation of SPS information as a potential example of excellence. An overview navigational display presents all SPSs. From this display, the system operator can navigate to a detailed status display for a particular SPS. Any SPS status change is alarmed to the operators. Telecontrol operators
also monitor the SPS schemes in their footprints. All functions of the SPS schemes are
documented thoroughly in HQ-T’s operating procedures, reference documents, and EMS. In
the on-site interview, the CCR system operator indicated that additional training may be
needed for some of the newer SPS schemes. The audit team recommends that HQ-T provide
this training if needed.

13. System Restoration

The transmission operator must have a documented system-restoration plan that must be provided to
the reliability coordinator.

The transmission operator must be prepared to restore its transmission area following a partial or
total collapse of the system and coordinate system restoration with its neighboring transmission
operators and with the reliability coordinators.

HQ-T has developed one overall system restoration plan in operating procedures 33199-U-001 and
GEN-R-067. The thorough and prescriptive procedures serve as a checklist for the blackstart and
restoration process. Telecontrol must ensure their specific instructions are consistent with this plan.
Following a blackout, Telecontrol operators independently blackstart their systems unless
unexpected system conditions or equipment failures necessitate discussion with CCR system
operators.

HQ-T’s blackstart strategy includes five major paths that link the blackstart generation to the load
centers. Nearly all of HQ-T’s units are blackstart-capable hydroelectric facilities. In accordance
with NPCC requirements, HQ-T tests each blackstart unit annually.

HQ-T dedicates two blackstart resources for each path to provide redundant sources for cranking
power. These five paths along with energy from neighbors create seven or eight islands.
Telecontrol operators manage these islands completely until it is time to synchronize them. CCR
transmission operators coordinate the synchronization, direct the restoration of the interconnections,
and direct the synchronization of Alcan’s and Brascan’s systems to the grid. HQ-T’s customized
EMS displays use real-time data to guide the CCR system operators when restoring the system.
These displays are cited as a positive observation by the audit team.

HQ-T’s generation travels great distances via the bulk power system to reach its load centers. As a
result, transmission system outages greatly impact HQ-T’s restoration strategies. HQ-T’s operations
support staff updates its restoration plan daily to account for equipment outages and notifies the
system operators of the modified strategies through memorandums. This practice is a potential
example of excellence. HQ-T maintains a list of key facilities and associated critical components
which impact its system restoration plan.

In response to a blackout, HQ-T implements its System Control Emergency Plan, which invokes its
emergency response organization. This organization directs communications regarding the blackout
and subsequent restoration. This approach allows the CCR and Telecontrol operators to focus
wholly on restoration and not be distracted by communications with external entities such as the
media and governmental agencies.
CCR system operators participate in NPCC-sponsored restoration training seminars. Internally, HQ-T provides system restoration training twice per year for the CCR system operators, using round table exercises for the five main paths, and once per year for the satellite operators. Generator personnel are not currently included in these annual exercises. HQ-T recently developed a valuable interactive, computer-based training exercise for system restoration. The audit team recommends that every CCR system operator participate in this training. The audit team also recommends that HQ-T develop a scenario-based joint restoration drill that includes CCR and Telecontrol operators and generating plant operators. Drills provide a valuable opportunity for the system operators to practice the coordination required for system restoration.

HQ-T has developed extensive operating procedures to address the power needs at critical substation and telecommunications facilities during a blackout and restoration. This level of documentation is noted as a positive observation by the audit team.

14. Equipment Maintenance and Testing

The balancing authority/transmission operator must ensure that transmission and generator relay maintenance is carried out as per the established requirements of the generator operator, transmission operator, NERC region, and/or NERC.

HQ-T’s transmission equipment protective maintenance program is based on NPCC Document A-04, which requires maintenance intervals of two to six years depending on the equipment being protected and whether the relays are electromechanical, solid state, or microprocessor-based. HQ-T completed its program in 2004 and is on schedule in 2005. HQ-T’s operations department reviews the workload remaining at the beginning of each month in the fourth quarter and adjusts the outage plan to meet the annual schedule. HQ-T’s transmission and generator relay maintenance and testing program is governed by the program strategy, specific standards for each type of protection system, the specific steps to perform the maintenance, and a schedule in its Maximo maintenance management system.

Following any system event, HQ-T analyzes its relay protection performance and SPS response. From these investigations, HQ-T develops corrective actions for any relay or SPS misoperation and changes its operating procedures and simulation assumptions when needed. HQ-T utilizes disturbance monitoring data to validate system and equipment performance characteristics. It then updates the system models in the Oracle database used by the planning and operations organizations. HQ-T disturbance monitoring equipment is synchronized to the global time standard using the Inter Range Instrumentation Group (IRIG) B protocol.

HQ-T maintains redundant metering at the interconnection points and compares both meters’ monthly readings to detect metering errors. If there is an error, a reading from the state estimator or from Telecontrol is used to tell which meter is wrong. HQ-T calibrates its interconnection meters annually in the presence of the neighbor’s representative.

15. Capacity and Energy Emergency Plan

Each balancing authority must have a capacity and energy emergency plan that address the following functions. (It should be noted that some of the items might not be applicable, as the responsibilities for the item may not rest with the entity being audited.)
1. **Coordinating functions.** The functions to be coordinated with and among neighboring systems. (The plan should include references to coordination of actions among neighboring systems when the plans are implemented.)

2. **Fuel supply.** An adequate fuel supply and inventory plan that recognizes reasonable delays or problems in the delivery or production of fuel, fuel switching plans for units for which fuel supply shortages may occur, e.g., gas and light oil, and a plan to optimize all generating sources to optimize the availability of the fuel, if fuel is in short supply.

3. **Environmental constraints.** Plans to seek removal of environmental constraints for generating units and plants.

4. **System energy use.** The reduction of the system’s own energy use to a minimum.

5. **Public appeals.** Appeals to the public through all media for voluntary load reductions and energy conservation including educational messages on how to accomplish such load reduction and conservation.

6. **Load management.** Implementation of load management and voltage reductions.

7. **Appeals to large customers.** Appeals to large industrial and commercial customers to reduce nonessential energy use and start any customer-owned backup generation.

8. **Interruptible and curtable loads.** Use of interruptible and curtable customer load to reduce capacity requirements or to conserve the fuel in short supply.

9. **Maximizing generator output and availability.** The operation of all generating sources to maximize output and availability. This should include plans to winterize units and plants during extreme cold weather.

10. **Notifying independent power producers.** Notification of cogeneration and independent power producers to maximize output and availability.

11. **Load curtailment.** A mandatory load-curtailment plan to use as a last resort. This plan should address the needs of critical loads essential to the health, safety, and welfare of the community.

12. **Notification of government agencies.** Notifications to appropriate government agencies as the various steps of the emergency plan are implemented.

13. **Notification to balancing authorities and reliability coordinators.** Notification should be made to other balancing authorities and to the reliability coordinator as the steps of the emergency plan are implemented.

HQ-T has two well-developed capacity and energy emergency procedures. The first, 33199-D-012, provides direction when HQ-T requests or receives a request for emergency energy. The second, 33199-I-001, helps the system operator determine the minimum level of operating reserves and how to restore them when deficient. CCR operators require support from the satellite and plant operators to implement the plan. CCR system operators direct the Telecontrol operators who take the required actions. Separate HQ-T procedures direct a voluntary customer appeal and implement interruptible customer programs. CCR system operators have up to 10,000 MW available for rotating load shedding as a last resort. CCR system operators notify the adjacent reliability coordinators via the RCIS when activating the plan. Notifications to the generating plants and the satellite centers are also specified in the procedures.
HQ-T provides annual training on the capacity and energy emergency procedures. The person responsible for the annual document review presents the training to the system operators and the system scheduling group prior to the winter peak. HQ-T’s training department is developing a capacity deficiency simulation module.


The transmission operator must have a documented vegetation-management program.

HQ-T procedures ensure that vegetation or other objects on the transmission rights-of-way do not impact the energized conductors. These procedures specify the line clearance requirements and the vegetation management maintenance cycle. Due to Québec’s climate variation, the cycle varies from three years in the south to 15 years in the north. Transmission corridor activities are administered by HQ-T’s transmission maintenance organization. Rights-of-way inspections are performed annually and the program is on schedule. HQ-T attends to problem areas mid cycle and promptly removes danger trees.

HQ-T is exploring a new technology to mitigate the impact of icing on its transmission lines, a condition that could cause excessive line sag, accidental vegetation contact, or tower failure. The prototype system works by opening an impacted transmission line, shorting all three phases of one end, and injecting a DC current on the other end to increase conductor heating and help melt the accumulated ice.

17. Nuclear Power Plant Requirements

Nuclear power plants must meet regulatory requirements for voltage and power in both normal and abnormal operating conditions (n-1 and system restoration).

HQ-T has only one nuclear plant within its footprint, Gentilly-2, and the plant is connected to non-bulk power system 230 kV lines. The Telecontrol operator is responsible for oversight of the transmission system and voltage control. The Canadian Nuclear Safety Commission has regulatory jurisdiction over the operation and maintenance of the plant. HQ-T does not have an operating agreement with Gentilly-2 but operating procedure GEN-D-058 and reference document GEN-R-058 contain critical transmission configuration information and voltage thresholds for the nuclear plant. HQ-T last performed a safety analysis for Gentilly-2 in 2002 and is now updating the report per the three-year regulatory requirement.

HQ-T respects these nuclear plant limits in all planning evaluations, and LIMSEL’s limits already factor in the nuclear plant requirements. Gentilly-2’s load requirement is documented and incorporated into the planning analysis. Voltage regulating equipment installed on Gentilly-2’s auxiliary buses provides optimal flexibility to respond to transmission system conditions, an approach noted as a positive observation by the audit team. Therefore, HQ-T’s voltage operating requirements do not restrict Gentilly-2. Additionally, Gentilly-2’s emergency power supply is provided by a separate gas turbine power plant located at the nuclear plant site. Gentilly-2’s emergency power supply configuration results in fewer restrictions for HQ-T’s four 230 kV lines connecting to the plant. HQ-T is obligated to provide a source from one of these lines within one hour should the gas turbine emergency supply fail.
Normal and emergency communications between HQ-T and the nuclear power plant are governed by operating procedure GEN-D-973-TRO.
Confidential Discussion

APPENDIX 1: Critical Energy Infrastructure

The following discussion is presented under private letter to the audited organization only and will not be included within the public version of the report.
APPENDIX 2: Audit Participants

The following discussion is presented under private letter to the audited organization only and will not be included within the public version of the report.
APPENDIX 3: Documents Reviewed

The following discussion is presented under private letter to the audited organization only and will not be included within the public version of the report.