Twelfth Quarterly Monitoring Report on the Integration of Power Supply Facilities to the Island Interconnected System

Presented to:

The Board of Commissioners of Public Utilities
Newfoundland and Labrador

Presented by:

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1. Purpose of this Report

This report examines second quarter 2021 scheduled and completed activities undertaken as part of the Transition to Operation (TTO) organization's role in getting the Lower Churchill Project (LCP) assets integrated into the province's electrical system. It represents the second quarterly report following resumption of that cycle, which had been replaced, starting in May of 2020, by monthly reviews. COVID-19 restrictions continued to foreclose in-person interaction with Nalcor and Hydro personnel in the preparation of this report.

During the quarter recently ended we participated in the Reliability and Resource Study Review – Technical Conference #3 on June 9, 2021". The topics included:

- The LIL Failure Investigations and Response
- The LIL Reliability Assessment
- Near-Term Reliability, Transmission Planning Criteria and Asset Health and Performance.

We reviewed Hydro's June 3 Reliability and Resource Adequacy Study Review – Labrador-Island Link Monthly Update report for the month of May. We sent to Nalcor a detailed list of agenda

items for discussion. We then reviewed the July 8 LIL monthly update report for June. We participated in July 15 and July 20 meetings to discuss our agenda items with Nalcor representatives. Following these two meetings, TTO provided written materials responsive to our agenda items and to topics that emerged at the meetings. Nalcor completed the provision of that information on July 28 - - this last submission included a delayed response from its Human Resources organization about progress in staffing the organizations responsible for LCP asset operation and maintenance.

2. Summary of Major Observations

Despite significant advances in LIL commissioning during the first quarter of 2021, uncertainty about getting the LIL into reliable, bi-pole commercial operation by the start of the coming winter had emerged. The schedule at the time of our review of first quarter 2021 progress placed LIL completion at mid-November 2021, just a few weeks before the coming winter, with that date subject to significant risk. Strong progress in key activities during the second quarter of this year brought an advancement in LIL completion to October or November. The more significant observation, however, is a potential material reduction in risks of delays that could push LIL completion perhaps well into the coming winter.

Risk still remains in key areas, such as valve hall beam replacement and completing the Final Software that will allow the LIL to operate at full capability. Nevertheless, those risks are now significantly lower, as beam replacement and software completion have passed important thresholds. The second quarter of this year, unlike most others, has not generated offsets to progress with the emergence of new problems or complications. Progress in resolving issues at the Muskrat Falls generators and in installing elliptical bearings to mitigate excessive vibration on the three Soldiers Pond synchronous condensers also proved encouraging.

TTO also continued to make steady progress in completing what now comprises a very small and steadily decreasing number of activities required of it. Moreover, following years of effort, a breakthrough in resolving issues delaying MPPA and IOA execution appears to have placed them on a path to completion.

Despite progress in completing the LIL, the overhead line has been out of operation since mid-June, to accommodate replacement of the defective valve-hall beams. Prior to the shutdown for beam replacement, the LIL operated at up to 225.75MW, but only for 400 hours starting April 1, limited by system conditions and needs rather than LIL condition. Defects in the process of manufacturing the new beams had delayed the replacement process, but correction of the manufacturing problem has supported an expectation that all replacement beams needed will be delivered to the site by July.

Nalcor expects to complete Pole 2 beam replacement first, followed by completion of Pole 1 replacement before or at least by the estimated delivery date for the Final Software to the site. If so, recommissioning will not require continued use of the Interim Software. Significant progress has been made on the Final Software. GE has completed software development and conducted testing that precedes the key Factory Acceptance Testing (FAT) milestone. The earlier testing performed recently has, however, identified bugs. GE needs to make corrections before

performance of the FAT that precedes the use of the Final Software (the first version that will support the full capabilities designed into the LIL). Addressing bugs has delayed expected FAT completion to August 10. Delivery of successfully-tested Final Software to the site by mid-August, while still wisely considered to be at some risk by Nalcor, can allow completion of dynamic commissioning and Trial Operation in time to permit the LIL to become fully operational by October or November of this year.

The events and activities of this year's second quarter brought significant progress in mitigating the risk that the LIL will be unavailable or limited in its capabilities for the coming winter. Valve hall beam replacement and Final Software progress have substantially reduced the risks to pre-winter operation that we cited in our report addressing the first quarter of this year.

Progress in completing the three Soldiers Pond synchronous condensers (SCs) also continued. SC3 is in the process of turnover to Operations, and Nalcor expects SC2 to follow SC3 into commercial operation imminently, further followed by SC1 in October. Monitoring continues to show substantial vibration reductions following the installation of replacement, elliptical bearings - - first on SC3. Measurements of radial/lateral vibration have shown it within the applicable technical specifications for SC3 (the only unit for which vibration monitoring reports now exist).

Concern among Nalcor experts exists about measurements of the other (axial) vibration types that has proven troublesome. However, those measurements for which results reports exist took place with SC3 temporarily operated when filled with air. After refilling it with hydrogen (its expected normal state during commercial operation), axial vibration measurements became unavailable. Nalcor has confidence that installation of permanent SC monitoring equipment will produce readings sufficient to identify before the warranty period expires any defects covered by warranty.

As before, however, Nalcor remains reluctant to offer views on long-term impacts from any vibration-inducing conditions not exposed during the warranty period or covered by warranty.

Repairs to the LIL overhead line facilities in Labrador damaged in last winter's ice storm have been completed. Drone-based surveying is underway to identify other weather-related risks, and plans exist for the installation of anti-galloping devices for seven spans this fall and for longer-term investigation of other areas at risk of failure due to galloping. Before this coming winter, management anticipates revision of the emergency plan for the LIL overhead line, ensuring the availability of 24-hour road clearing resources as needed, and the retention of a contractor who can provide personnel, equipment, and expertise to augment already existing emergency repair resources.

Repairs to the electrode site damaged by wave action last December have also been completed. Nalcor expects by this coming October a report from an outside firm evaluating the design basis of the site in light of expected wave return periods. That report will recommend any necessary modifications. Such modifications would be scheduled for 2022 construction. In the meantime, a lack of monitoring at the remote electrode site location leaves Hydro at risk of underfrequency load shedding should a similar, unrecognized failure cause a LIL monopolar fault developing into a bipole failure.

TTO progress nears completion of its mission, having advanced well during the past quarter. Its activities do not appear to present major schedule threats to LCP schedules, although important activities continue to await completion. Staffing the operations organization, developing and providing required training, Muskrat Falls site emergency planning, securing agreements with outside contractors, and building out ongoing maintenance programs have all proceeded at a pace supportive of turnover to operations at a pace consistent with completion of work to place the LCP assets into commercial operation. Completing an important maintenance contract with Andritz and the emergency response plans remain important priorities.

MPPA/IOA finalization now has a scheduled completion date; the parties have an agreement in principle on the remaining issues; and assigned teams continue to work to develop specific agreement language to address those resolved issues.

3. Detailed Findings

a. LIL Progress

The key factors affecting LIL schedule in the second quarter of this year included:

- The need to halt operation of both poles due to deterioration of the affected beams and their replacement
- A manufacturing issue affecting some of the beams - - since corrected
- Delays in the completion of the Final Software.

From April 30 to June 18, 2021, the LIL carried approximately 50 GWh from Labrador to Soldiers Pond (with 47.3 GWh delivered - - the remainder being the power loss). This included 400 operational hours (349 hours on Pole 1 and 51 hours on Pole 2). The maximum power transfer from Muskrat Falls (MF) was 225.75 MW (for two days only). Transfer levels varied, mostly between 130MW and 150MW, with Pole 2 in operation on only four days and Pole 1 on 18 days.

Nalcor notified the Public Utilities Board on June 18 that the LIL would be offline until late July to allow for the completion of valve hall beam replacement efforts. Both Pole 1 and Pole 2 will remain out of service until contractors complete the beam replacement work in the Pole 2 valve hall. The decision to shut down both poles resulted from GE work over the past several months. That work included regular inspections of the valve halls and beam resistivity checks to ensure adequate maintenance of required insulation resistance levels under the interim vale hall solution (cleaned and re-cured beams). More recent measurements showed that the beams deemed defective (Rochling beams) were deteriorating further. Due to the high risk of operating LIL with low resistivity beams, GE decided to keep the LIL offline pending replacement of all defective beams. The manufacturer initially used two production lines for the replacement beams; GE rejected the beams from one of the lines, but the issue was corrected re-establishing full productivity. Nalcor reports beam production issues as remedied sufficiently to meet GE's requirements.

Nalcor reports that replacement has gone well, with completion of all beam replacement for Pole 2, which can now operate utilizing the Interim Software following the completion of three days of valve testing. GE also performed a firmware upgrade on the Human Machine Interface. Pole 2 was ready for operation on July 23. Beam production and delivery to site continues for Pole 1. An

accelerated delivery schedule for remaining beam replacements is expected to support completion of work on Pole 1 at or before the expected delivery of the Final Software (around August 13). Meeting the current Pole 1 replacement work completion and Final Software delivery dates will permit the use of that software for final dynamic commissioning of the LIL. A delay in availability of the Final Software will require the LIL to transfer power with the Interim Software.

The Final Software remains in test mode, with some known issues still present. FAT has commenced and management expects all important issues will be fixed before the installation of the Final Software at site. FAT testing is expected to take two weeks, producing the August 13 expected completion date.

Base development of the Final Software has been complete for some time. It has undergone Integration Testing and the first phase of Factory Systems Testing. The identification of bugs that require correction has caused a 12-day extension of FAT. Recognizing risks in completion by this revised date, meeting it can support a September 19, 2021 completion of commissioning. These activities are expected to include six weeks of dynamic commissioning of the LIL Bipole (using the Final Software) to test the full LIL functionality. Successful completion of dynamic commissioning will begin another Trial Operation period, at available power. Successful Trial Operation requires 30 continuous days of operation without an unintended trip, which must be accomplished within a window of 60 days. Should trips leave less than 30 days remaining from the overall 60-day window, GE will provide a root cause analysis and explain remedial measures for Nalcor approval to commence a second 60-day window. Thus, a September 19 start of Trial Operation can support achievement of that major milestone by late October or November of this year.

b. Synchronous Condensers

Commissioning of Synchronous Condenser Unit 3 (SC3) has been completed, GE has performed additional tests to demonstrate the capability of the unit. The process of turning over SC3 to Operations is underway. Dynamic Commissioning of SC2 began on May 25 and on-grid testing on June 11, 2021. Commissioning was completed on June 24. Nalcor expects completion of Special Field Tests that require two SCs in service by the end of July, after which SC2 will enter Commercial Operation. Reassembly of SC1 with the elliptical bearing designed to address the vibration issues has been completed and static commissioning has begun. The schedule calls for inception of SC1 dynamic commissioning on August 5, and on-grid tests on September 20, 2021, with turnover to Operations on October 30, 2021. The identification of the need for dynamic testing beyond that previously anticipated moved this date out from September.

Measurement of radial/lateral and axial vibration employing special equipment installed has continued as SC3 and SC2 have operated. Only SC3 has produced reported data. Some of the SC3 data exists only for the time when it temporarily operated in air, as opposed to permanent operation using hydrogen (begun in late 2020). The means for measuring axial vibrations did not remain available following conversion to hydrogen. A GE report to Nalcor about SC2 vibration levels remains pending.

Nalcor has reported that the applicable technical specifications require that vibration amplitudes do not exceed those of ISO 7919-5 Zone B. The SC3 data collected show radial/lateral readings within the Zone B levels and at GE "deemed safe levels" (specified/guaranteed).

Measurements of axial vibration were available during SC3s October 2020 operation when filled temporarily with air, but not during November operations after filling with hydrogen. Some of the experts Nalcor uses have expressed concern about the October axial vibration levels. These concerns led to the installation of permanent equipment that has produced axial vibration readings that the pending SC2 report from GE will address. Nalcor continues to express confidence that the installed instrumentation and monitoring will detect possible defects during the warranty period, but its management has continued not to offer views on long-term (post-warranty) impacts on the units.

c. HVDC OHL

All repairs required to restore power transfer capability to the LIL overhead transmission line (OHTL) in Labrador have been completed. Investigations are underway to determine if additional work is required. A drone-supported inspection now underway will identify further required work to repair damage from last winter's ice storm or to address any other issues disclosed by the inspection underway. Management plans to install anti-galloping devices (air flow spoilers) in the southern Labrador region, covering seven spans determined to be at galloping risk. Following expected equipment arrival in October, installation will take about a week. Longer term, management is investigating the risks of similar exposure at other locations and means for addressing any found across the line's full length, for consideration as part of the overall Reliability and Resource Adequacy Study.

Management believes that the +/- 2km range of drones makes them unsuitable for gaining access to repair locations. It will continue using contracted and internal helicopters, supplemented by alternate land vehicles to address the unavailability of helicopter access in emergency repair situations under adverse weather conditions. Management plans to secure 24/7 availability of additional road clearing resources to expedite access to repair locations. Nalcor also has under preparation a solicitation designed to secure by this coming October access to resources from an additional line contracting company that can provide power line technicians, engineering expertise, heavy equipment, and tooling to expand resources available to address line failures.

d. Sea Electrode Issues

Repairs to address damage at the L'Anse aux Diable Electrode Site following the December 2020 storm were completed in May. An award for design review of the site has been awarded to a structural engineering firm. The review, expected to produce a report by this coming October, will include analysis of local site conditions, physical layout, weather exposure and wave action for use in evaluating the applicable design criteria and in identifying the need for any required site modifications. The evaluation of design criteria will include the application of local data, including wave height return periods. It will determine the nature of the failure that resulted in the electrode outage.

Should proposed modifications result, Nalcor expects construction during 2022. In the meantime, an absence of regular monitoring of this remote site leaves it exposed to damage that may not be

recognized. Should that be the case, Hydro risks the possibility of underfrequency load shedding (UFLS) should a monopolar LIL fault lead to a bipole failure.

e. Muskrat Falls Generators

The second quarter brought substantial progress in modifying the Muskrat Falls generating units to address design issues summarized in our most recent report. Those modifications will allow higher stress levels in the bolt arrangement between the turbine inner and intermediate head cover at each of the four units. Units 1 and Unit 2 remain idle with the LIL out of service for valve-hall beam replacements. Welding rework and head cover modifications remain ongoing at Unit 1, as does planning for generator stator bar replacement. Restart of Unit 1 has been tentatively set for mid-August.

Unit 2 modifications are complete, overspeed testing has been performed, and the unit is available for operations. Unit 3 post overspeed inspections have been completed with no issues identified. Commissioning has resumed, with Unit 3 synchronized to the grid on July 16, achieving First Power. Online testing has continued, with the forecasted Ready for Operations remaining at the end of July 2021. Unit 4 installation activities have neared completion. Unit 4, bulkhead removal has been completed and static commissioning activities are ongoing. Release for service is expected in September 2021.

The Muskrat Falls reservoir is at full supply level (FSL) of 39.0 m, and has been maintained at FSL since impoundment. With only one unit in service for the year to date there has always been a discharge through the Muskrat Falls spillway, easing the sustaining of FLS. Inflows into the Muskrat Falls reservoir have exceeded average levels so far for 2021 and planned releases (spills) have been made from the Churchill Falls reservoir through the spring and early summer of 2021.

f. Overall TTO Schedule Statis

We continue to measure overall schedule status using activity progress and an overall cumulative percent complete S-curve metric. The S-curves graphically depicted cumulative progress of the TTO project on a percent complete basis (actual percent complete versus planned percent complete). TTO activity completion as of June 30, 2021 was at 97.3 percent complete, compared with last quarter's quarter 96.3 percent and a planned 98.5 percent for this quarter. The following table summarizes the planned vs. actual status by work stream.

Work Stream	Planned	Actual
BTPO	98.2	96.6
RFI	99.1	98.6
RFCI	98.9	98.1
Total	**98.5**	**97.3**

TTO completion of 952 activities compares to its target of 966 activities. As of June 30, 2021, 93 activities out of a total of 1045 remain open. The majority of the open activities fall within the categories discussed below. TTO also had substantial success in reaching its major milestones; of the original TTO scheduled 32 milestones, only 5 remain open. Detailed TTO activities associated

with those five milestones now number only 17, with the majority of them tied to full power accomplishment of Muskrat Falls generation.

g. Staffing

As reported last quarter, the original TTO staffing commitment called for:

- Transmission O&M Staff: 58
- Generation O&M Staff: 28
- Engineering Services Staff: 41
- Support Services Staff: 14.

From this original plan total of 141 (excluding BTPO staff), only one position remains unfilled (a Muskrat Falls contract administrator). Filling the position remains on hold as part of a larger hold on new hires pending organization changes with Nalcor Energy and Hydro.

Subsequent changes to the organization fall under Nalcor Human Resources. The next chart shows complements and vacancies using the current Nalcor organization structure and alignment.

Organization Title	Complement	Vacancies
Transmission Operations Work Mgmt. and MF	25	0
Transmission Operations Soldiers Pond	42	5
Power Supply Production & Energy Marketing	38	8
Engineering Services	5	0
Engineering Services Operations Support	25	0
Engineering Services Project Execution Gen.	27	1
Eng. Services Business Services	26	3
Portfolio Asset Mgmt.	12	0
Totals	**200**	**17**

Management still records five Hydro Operations positions as vacancies (these show in the Power Supply Production & Energy Marketing total above), but Manitoba Hydro International (MHI) personnel fill these operations positions under a services contract. As we reported last quarter, management extended the MHI contract through 2022. Nalcor previously added five apprentices; management plans for them to fill the presently-contracted positions eventually. The remaining 12 vacancies comprise a combination of positions, the status of which management will assess in the future. A hiring freeze exists pending the announced restructuring of Nalcor/Hydro. It will assess post-reorganization assessment of continuing needs for the open positions. The number of vacancies fell from 20 last quarter to the 17 shown in the preceding table. We did not find the resulting 8.5 percent vacancy figure unusual or troubling under the circumstances.

h. Training

Training divides into two phases. Phase I encompasses training associated with asset release for service and Phase II with follow-on, detailed maintenance program programs and activities. Nalcor has indicated that it has completed all Phase I training, except for two sessions. Nalcor has also indicated that some Phase II training may likely be delayed until the third quarter of 2021. Recent specific accomplishments and plans include:

- Delivery of two GE HVDC training courses brought the total completed through April to 11 of 13 planned, with the remaining two required to wait because they entail hands-on training after full systems commissioning
- ATCO's delivery of dc operations training has moved to 94 percent complete, with targeted completion moving to third quarter 2021
- All five TTO synchronous condenser courses are complete
- All six Phase 1 turbine and generator sessions are complete
- One of the Phase II turbine and generator sessions is complete, with the remaining sessions scheduled
- 14 of 16 Muskrat Falls balance of plant courses are complete
- Balance of plant Phase II maintenance training sessions began in the second quarter, with 12 of the 16 sessions complete
- MFG spillway intake and gate systems courses are now 83 percent complete, an increase from a previous reported 67 percent complete.

i. Muskrat Falls Site Emergency Response Plans and Guidelines

We asked about two overall site Emergency Response Plans (ERPs): one for Muskrat Falls and one for the LIL. The Muskrat Falls plan focuses on the generation site, but includes some remote sites. The LIL plan focuses on Soldiers Pond, but also covers some remote sites. At this time, the Muskrat Falls generation team operates under the LCP ERP because the LCP project team still "owns" the site and provides management of emergency response services. The Soldiers Pond site teams have an interim ERP, with the final version under review for acceptance at full project completion. Several ERP schedule activities show a low percent complete at this time, but scheduled completion by the end of the coming quarter. That completion is important for project turnover to operations.

j. O&M Contracts

All (56) transmission O&M contracts within the TTO plan are complete and turned over to operations. Fifty-one of the sixty-one generation O&M service contracts are complete. Four contracts relating to inventory spares and the establishment of the long term MF warehousing will likely complete outside the TTO schedule. The remaining contracts, which cover ongoing services, are behind schedule due to continuing negotiations with a major LCP contractor (Andritz) that management would like to utilize as an ongoing service provider. We do not know how substantial may be the issues to close out the Andritz pre-operations contract(s), but it is not unusual to find interest in completing such matters before executing agreements for ongoing support or services.

It is also typical for contractors to provide immediate-term services on a "one-off" basis pending completion of negotiations to close out old contracts or execute ongoing ones.

k. Generation Corporate Health and Safety

One activity in this work stream remains open. This final item, completion of the Lightning Protection Program currently sits at 95 percent completion, with final completion scheduled for August 31, 2021.

l. Emera Agreements

One activity, the Regulation Service Agreement is open at this time. This activity is 94 percent complete and scheduled for completion by the end of this month.

m. Build Out of the Maintenance Programs

This category of activities consists largely of preventative maintenance (PM) activity scope and equipment check list activities. TTO divides the work into two categories to support prioritization of the more critical activities. The higher priority addresses PMs that must be performed frequently, with the second priority on PMs repeatable over a longer cycle. The high frequency PMs comprise those typically performed on a daily, weekly, or monthly basis. Lower frequency PMs may occur on cycles of perhaps once a year, or less frequently. Nalcor has reported all high frequency PMs as complete, with work now focusing on completing the low frequency ones. Low frequency PMs remain at a relatively low percent complete. All PM planning activities are scheduled to be complete by end of September 2021. Liberty will continue to focus on these activities to completion, although we do not see an immediate operation concern in this area.

n. MPPA/IOA Progress

Potential impacts on the interests of CF(L)Co, and particularly the rights of Hydro Quebec related thereto, have proven a long-standing barrier to reaching agreement on the MPPA and IOA agreements. After negotiations extending over an extended period, the parties eventually decided to engage a mediator to assist in resolving the 10 or so major issues that remained outstanding in reaching agreement on the IOA, which will be between the two provincial system operators. Following January and April 2021 sessions, the parties reached high-level agreement on all the outstanding IOA issues. The CF(L)Co board of directors then conditionally approved the MPPA, subject to completion of the IOA in line with resolution of the 10 issues mediated. With broad level IOA agreement reached, detailed negotiations between the Newfoundland/Labrador System Operator and Hydro Quebec are continuing, with CF(L)Co observing. Nalcor believes that no material hurdles remain to resolving the more technical matters under discussion. Nalcor anticipates IOA completion in January 2022, upon which MPPA completion will follow.