MUSKRAT FALLS TRANSMISSION LINE REVIEW

Dated:

October 12, 2016

Prepared for:

The Consumer Advocate NL

Commonwealth associates, inc.

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Prepared by:

Yair Berenstein, P.Eng.
Project Engineer

Approved for submittal by:

Richard N. Collins, P.E.
Vice President
Transmission & Distribution Engineering
& Environmental Services

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IN THE MATTER OF
the *Electrical Power Control Act,* 1994, SNL 1994, Chapter E-5.1 (the *"EPCA")* and the *Public Utilities Act,* RSNL 1990, Chapter P-47 (the "*Act*"*),* as amended;

AND

IN THE MATTER OF
the Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System.

EXECUTIVE SUMMARY

Engineering consultant Commonwealth Associates, Inc. (Commonwealth) has been retained by the Consumer Advocate (CA) to evaluate and provide our professional opinion concerning whether the Newfoundland and Labrador Hydro Corporation ("Hydro") and its affiliates, including parent company Nalcor Energy ("Nalcor"), have adequately addressed the risks to supply presented by electrical transmission systems serving the island of Newfoundland following construction of the Labrador-Island HVdc transmission system (LITL) and after interconnection with the Muskrat Falls generating facility. In particular, the CA has requested our professional opinion on the structural and mechanical risks to the reliability of electrical transmission systems serving the eastern portion of the island of Newfoundland after the aforementioned construction and interconnection

Areas of concern identified during our review prompted Requests for Information (RFIs) from Hydro. Those concerns included: a non-standard choice of pole conductor, guyed tangent structures, questionable soil condition assumptions underlying foundation and anchor decisions, the proximity of line locations within the corridor, lack of load cases related to cascading failure risks with respect to suspension tower types A and B, and return year discrepancies.

Responses filed by Hydro to our RFIs were insufficient for us to provide a more thorough assessment of risk and reliability. With that in mind, our findings and recommendations are as follows:

1) A risk assessment of transmission overhead line reliability cannot be performed with available documents and current RFI responses.

2) Nalcor states in their response to NP-NLH-004 (page 7 of 57) that the design of the LITL meets a 1:500-year reliability return period for the portion of the line on the Avalon Peninsula and a 1:150-year reliability return period for the remainder of the route. However, no specific design details were

provided by Nalcor to back up this claim. These requests were made in several RFI's from multiple stakeholders.

3) It is recommended that an "as-built" risk/reliability assessment be performed after construction to find possible mechanical weak points.

BACKGROUND

Figure 1

The Consumer Advocate (NL) has secured the professional services of consulting engineers, Commonwealth Associates, Inc. to provide expert opinion and insight into the proposed island interconnected system and proposed connection to Muskrat Falls generating facility [Fig. 1]. Commonwealth is a leading industry expert, having been profiled among the 2016 Top 10 U.S. Electrical Design Firms by *EC&M Magazine*[1]. Curricula vitarum for those Commonwealth professionals conducting and approving the review are attached as **Appendix A**.

The ±320 kV HVdc bipolar transmission line is approximately 1100 km long from the Muskrat Falls Converter Station to Soldiers Pond Converter Station. This includes lines across the island of Newfoundland from the Great Northern Peninsula to Soldiers Pond, near the Newfoundland and Labrador capital of St. John's. It is comprised of an overhead section from the Muskrat Falls Converter Station to the Strait of Belle Isle (SOBI), cable transition compounds on either side of the SOBI, an undersea cable marine crossing, and an overhead transmission line from the SOBI to Soldiers Pond. These lines and associated structures will be exposed to varied weather and ice. Salt will also be an issue.

[1] "Announcing EC&M's 2016 Top 10 Electrical Design Firms," ecmweb.com, May 27, 2016, http://ecmweb.com/design/announcing-ecms-2016-top-10-electrical-design-firms#slide-3-field_images-136251

The reliability of the new system is part of a public inquiry being undertaken by the Newfoundland and Labrador Board of Commissioners of Public Utilities in St. John's, NL. Typically, the reliability of the system, at a minimum, should be consistent with generally accepted reliability standards in the industry. Phase One of the inquiry concerns the adequacy and reliability of supply on the island interconnected system up to the interconnection with Muskrat Falls. Phase Two is focused on the implications of the interconnection with Muskrat Falls on reliability and adequacy of the island interconnected system. The following issues are expected to be addressed in this phase of the proceeding:

- The impact of the interconnection with Muskrat Falls on the island interconnected system;
- Island interconnected system structure and operations;
- The impact of the Maritime Link, including the availability of power over the Maritime Link
- Risk management.

Current practice of designing electric transmission lines includes the application of the following loading criteria: Climatic Loads, Security Loads, Construction and Maintenance Loads, and Code Loads.

Transmission lines in service today in the U.S. have been designed using a multitude of design approaches and structural loading criteria. The principal cause of structural failures is weather events that produce loads that exceed the structural loading design criteria. In some cases, failures have been the result of inadequate design, construction and/or maintenance practices, airplane or vehicle accidents, or criminal activities. Examples of weather events that can produce loads in excess of design loads are tornadoes, hurricanes, and long-return period (low probability) wind and ice storms. IEC 826 recommended collection of local weather data for the design of transmission lines. HYDRO sponsored a study by Asim Halder titled "Twenty Years of Monitoring Experience on Overhead Line in Newfoundland and Labrador". This paper discusses transmission failures due to icing in the Avalon Peninsula and resulted in a long term study of icing in the regions using the installation of weather stations to provide real time data. The purpose of these monitoring stations as stated on page 2 was "'...to predict the design wind and ice loads on an overhead line with an adequate confidence level." It seems that this data should have been used to determine the weather parameters for the design of the LITL lines rather than using the standard CSA/IEC figures that do not take localized weather into account. In RFI's CA-NLH-141 and NP-NLH-004 (page 2) it clearly states the ice and wind design loads are based on CSA standards.

REVIEW METHODOLOGY

Commonwealth identified the appropriate technical experts to conduct the review and to provide oversight for technical and report quality. The Transmission and Distribution Line Engineering technical team members have extensive experience in project management, transmission system planning and operations, load forecasting, and the design and optimization of high voltage transmission lines, including those spans over and under water crossings and those in extreme weather conditions. In addition, Commonwealth provides in-house consultative experts from other departments to advise and assist, as necessary. Those internal resources include professionals from the following departments: Substation Engineering, Power Generation and Energy Services, Electrical Systems Studies, Environmental Services, Land and Right of Way Services, and Project Support Services. A list of the document classifications reviewed to provide a basis for our professional opinion follows.

LIST OF DOCUMENTS REVIEWED

Commonwealth's evaluation of this project's reliability is based strictly on the review and study of existing documents available in the public domain. These documents consisted of:

- Exhibits from 1981 through 2014, many of which were regional design studies not specifically related to this particular project;
- Other reports or studies related directly to this project; and
- RFIs with corresponding answers related to the subject matter of this report from the following groups:
    - Consumer Advocate of NL
    - Grand Riverkeeper Labrador
    - Newfoundland Power
    - Public Utility Board

A list of the documents studied to form the opinions expressed in this report are listed in **Appendix B**.

DEVELOPMENT OF RFI'S CA-NLH-132 TO CA-NLH-141

During document review, the following were identified as areas of interest and potential concern, leading to development of RFI's CA-NLH-132 to CA-NLH-141. A discussion of the items in greater detail follows under applicable heading.

- The non-standard 3633 KCMIL 1841_A1/S1A-110/7 ACSR for the Pole Conductor, as noted in NP-NLH-018 is of potential concern. ACSR conductors typically used on high voltage overhead transmission lines are standardized in ASTM Standard B232. The conductor sizes and strandings in B232 have been thoroughly tested to meet all ASTM specifications and have been used over many decades with success.

- “Typical HVdc Transmission Guyed Tangent Structures which comprise approximately 85% of the towers in the Labrador-Island HVdc transmission line,” as noted on page 44 in the paper “Review of the Muskrat Falls and Labrador Island Link and the Isolated Island Options”, dated October 2012 by Manitoba Hydro International is of concern due to a susceptibility for a broken guy wire causing a possible cascading event and an extended outage

- The foundation and anchor quantities having been calculated based upon an assumed distribution of soil conditions (normal %/rock %/bog %), as noted on page 53 in the project report “Emera Newfoundland and Labrador Maritime Link Project, Engineering Review of the Project”, dated January 26, 2013 by HATCH. This methodology is of concern as it appears that design of the foundations have been estimated.

- The ac and dc lines are located in close proximity to one another within the corridor, which is of potential concern because of the possibility of one line failing and falling into the neighboring line. A bipole failure would be devastating to this system as noted in the Liberty report. We concur. On page 17 of the Liberty report it states that the “Hydro has clarified that, in t3eh event of a tower failure, the HVdc OHL has been designed so as not to fall outside the HVdc right of way. This will prevent failure of both the HVdc and HVac lines when run in close proximity to each other.” This is a blanket statement, much like the Reliability Return Period, with no facts provided to prove the two lines cannot physically damage the other if one tower should fail.

- There are no documented load cases in the design to limit the anti-cascading failure mode for the towers relative to the suspension tower types A and B, therefore no assessment of the reliability of the line in the event of a cascade failure can be made.

Below are the resulting RFIs and the corresponding answers received from Hydro. The focus of our inquiry was specifically on documents regarding the reliability of the design, specifically the structural and mechanical risks and principles of overhead transmission lines.

- **CA-NLH-132**: According to Emera Newfoundland and Labrador's *Maritime Link Project Report – Engineering Review of the Project*[2] dated January 26, 2013, the return periods for the wind, ice, and temperature combinations for the loading on the structures, conductors, and hardware is 50 years. Please explain why Hydro decided to use a 50-year return period for the wind, ice, and temperature for such an important line with so much transfer capacity.

  ANSWER: "Hydro notes that the information requested consists solely of a request for detailed technical information relating to engineering issues."
  "In Board Order No. P.U. 41(2014). The Board stated issues covered in the current proceeding "will not involve an analysis of engineering and construction issues associated with the Muskrat Falls Project" and "it is not necessary for HYDRO to provide detailed technical information or reports related to engineering and construction issues but rather should direct its response to the risks and consequences to the Island Interconnection system of the scenarios and issues raised."

- **CA-NLH-133**: For the overhead sections of the Maritime Link Project (230 HVdc), please provide the results for the full scale testing of the different structure types and the conductor optimization study to identify the optimum conductor type and size for the project.

  ANSWER: "Please refer to Hydro's response to CA-NLH-132."

- **CA-NLH-134**: According to Emera Newfoundland and Labrador's *Maritime Link Project Report – Engineering Review of the Project* dated January 26, 2013, all tangent structures in the NL section are proposed to be guyed lattice steel towers. Please explain how the structure selection was done.

  ANSWER: "Please refer to Hydro's response to CA-NLH-132."

- **CA-NLH-135**: According to Emera Newfoundland and Labrador's *Maritime Link Project Report – Engineering Review of the Project* dated January 26, 2013, the foundation and anchor quantities have been calculated based upon some type of distribution of soil conditions (normal%/rock%/bog%). Please provide explanation of methodology.

  ANSWER: "Please refer to Hydro's response to CA-NLH-132."

- **CA-NLH-136**: Did the selection of weather conditions for the development of the load cases on different elements of the transmission line include local monitoring system?

  ANSWER: "Please refer to Hydro's response to CA-NLH-132."

[2] Emera Newfoundland and Labrador, *Maritime Link Project Report*, January 26, 2013, http://www.emeranl.com/site/media/emeranl/Documents/App%203.01%20Technical%20Appendix.pdf

- **CA-NLH-137**: According to NP-NLH-038, Page 2, paragraph (g):

  "Clearances under maximum ice and after load- The line is designed for 8.3 m ground clearance for maximum sag condition with maximum ice after load condition or maximum temperature after load condition (85 deg. C)."

  Please explain how you derived this value? Please provide clearances and separation values to other objects with their related load cases.

  ANSWER Based on ground usage criteria "Over walkways or ground normally accessible to pedestrians, snowmobiles, and personal-use all-terrain vehicles" as per CAN/CSA 22.3 No. 1 Table 4, and 350 kV voltage, the base clearance is 6.0 m. Added to that amount are 1.4 m for snow cover, also as stipulated by CAN/CSA 22.3 No. 1-10, and an additional design buffer of 0.9 m to allow for inaccuracies in ground profile at the exact structure location, or to enable structure movement freedom during construction, in the event that a structure needs to be moved for constructability reasons. This totals 8.3 m.

  The clearance and separation value for the line structures were determined in accordance with the requirements of CAN/CSA 22.3 No. 1-10. Further examination of the detailed engineering design for the Labrador – Island Transmission Link is beyond the scope of this proceeding, as noted in Hydro's response to CA-NLH-132.

- **CA-NLH-138**: According NP-NLH-061, 062, 064, and other supporting documents, the structure locations have been determined in such a way that the maximum structure utilization for different load cases will be less than the structure manufacturer's design and testing. Please explain, from a reliability point of view, the effect on characteristics of the transmission system for identifying the critical elements.

  ANSWER: "The concepts identified in the above question are unrelated. To the extent that individual structures are loaded to less than their ultimate capacities, the result is that the structures have some capacity to withstand greater levels of wind speed and radial ice than the design load cases.

  Structures are also designed for the statistical worst case loading in a particular zone. Site specific features, such as sheltering, can reduce these loads to something less than the design load."

- **CA-NLH-139**: In reference to NP-NLH-038, Page 2, paragraph (f), please provide the additional load cases for the design of the anti-cascade towers relative to the suspension tower types A and B load cases. Please provide the layout drawing of the anti-cascade towers.

ANSWER: "Please refer to Hydro's response to CA-NLH-132."

- **CA-NLH-140**: Referring to *Manitoba Hydro International: Review of the Muskrat Falls and Labrador Island HVdc Link and the Isolated Island Options*[3], October 2012, page 46:

  "Provision of special anti-cascade towers every 10 to 20 structures to contain and isolate failures and prevent them from impacting large sections of line"

  Reference to NP-NLH-038, Page 2, paragraph (f), "Anti–cascade requirements dictated that a maximum of 20 suspension structures would be permitted between full–tension dead ends".

  Please explain the rationale for when the spacing between anti-cascade towers will be lowered to 10 structures instead of 20 structures.

  ANSWER: "There are no scenarios where the specified spacing between anti-cascade towers is lowered to 10 structures instead of 20. The Labrador-Island Transmission Link anti-cascade specification is that no greater than 20 towers be installed between anti-cascade structures.

  Dead-end structures capable of acting as anti-cascade structures (D and E tower families) are installed for other reasons, namely on turns or where tower up-lift would occur. Finally, situation may arise where it is less expensive to reduce the spacing between anti-cascade structures below the specified 20 in order to take advantage of topography to reduce overall tower cost.

  The specification, however, is a maximum of 20 structures between anti-cascade towers."

- **CA-NLH-141**: In reference to NP-NLH-004, please confirm that the conductors and hardware have been designed to a 1:150-year reliability return period. If that is not true, then what reliability return period was used to design these components?

  ANSWER: "Conductors, insulators, and hardware are designed to withstand loads greater than structures, and will withstand loads beyond those depicted in Hydro's response to NP-NLH-004, and therefore beyond the return periods as presented. The capabilities of these components are

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[3] Manitoba Hydro International, *Review of the Muskrat Falls and Labrador Island HVdc Link and the Isolated Island Options*, October 2012, http://muskratfalls.nalcorenergy.com/wp-content/uploads/2013/03/MHI-Review-October-2012.pdf

designed using strength factors beyond those of the structures in accordance with the CSA standard, rather than a reliability return period. "

We have reviewed the responses by Hydro to the RFIs. The responses to RFI Nos. CA-NLH-132 – 136, and CA-NLH-139 did not provide any of the requested, or any other, mathematical calculations, design specifications, or supporting documents. These mathematical calculations, which are part of normal engineering practice, disclose the extent to which a chosen design addresses the structural and mechanical risks to the reliability of electrical transmission systems.

Engineering design specifications for electrical transmission systems typically include, but are not limited to: tower loads and conductor sag-tensions; tower types; spans; tower top geometry; tower heights and extensions; load factors; strength factors; and similar requirements, as applicable, related to foundations, conductors, and insulator strings. In transmission line engineering practice, supporting documents which reflect detailed design are typically comprised of: 1) Microsoft Excel files; 2) back-up files of all tower models created using engineering software such as Power Line Systems TOWER; and 3) back-up files created using engineering software such as Power Line Systems PLS-CADD.

Commonwealth cannot provide any definitive comments on the overall tower design, insulators, and hardware, as these items have not been addressed in any reference documents. As we were not provided any access to the tower design details, proposed plan and profiles, or hardware details, we cannot comment on the route selection or transmission line risk analysis.

Figure 2 – Typical Guyed-Vee Transmission Tower

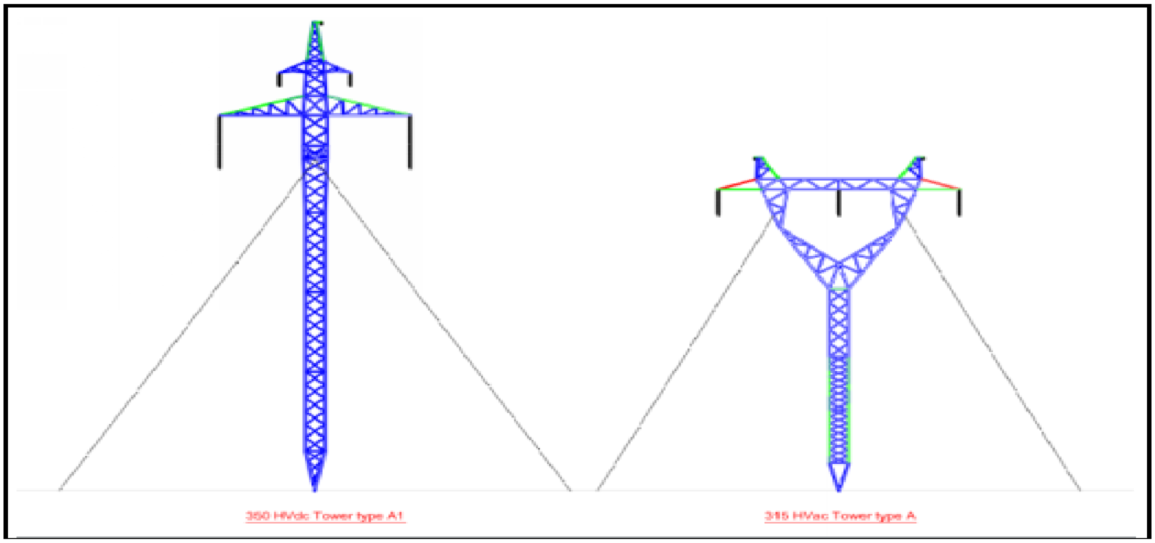

Figure 3 - Typical HVac and HVdc towers

FINDINGS AND AREAS OF CONCERN

Without the benefit of being able to review and link to the actual design documents, concerns about the following aspects of the design include:

- There are no singular comprehensive design criteria as far as we can surmise. Design criteria is normally the first step in the design of any transmission line; especially one as large and important as is this. This document would describe every detail with regard to all of the design decisions that drove the design. Any qualified transmission line engineer can read the design criteria and get a fairly comprehensive idea as to the how the line was designed. This document would also serve as a historical record for future upgrades on this line. The design criteria document was not provided to any of the stakeholders during the RFI process. The only data we found that provided some design criteria information was scattered in various studies, exhibits, and many documents from different dates and times. It appears the decision to change from a 1:50 Return Period to 1:150 was based on a recommendation from the paper "Review of the Muskrat Falls and Labrador Island Link and the Isolated Island Options", dated October 2012 by Manitoba Hydro International.

- The decision to adopt the IEC Standard and CSA Code for the design reliability criteria (NP-NLH-004) was not satisfied when designing with reliability-based methods for such an important new transmission lines. An evaluation of the impact of climate changes on the wind and ice return period needs be considered.

- Guyed-vee structure design cannot be properly validated with the lack of testing documentation, longitudinal design criteria, and cascade event control. The remoteness of this line presents a concern with a susceptibility for a broken guy wire causing a possible cascading event and an extended outage.

- The non-standard conductor has a lack of historical success. Standardized conductors are listed in ASTM Standard B232. All conductor manufacturers are competent to produce these standard conductors and have been for decades. These conductors have been tested and have a history of success in the field. Using a non-standard conductor poses many concerns. The conductor has likely not been manufactured before. The lack of commercial availability of a non-standard conductor could create an issue for future maintenance due to lack of immediate availability in the event of failure and the resulting pending need for additional non-standard conductor.

- Foundation calculation methodology appears to be to be estimated. This could be a reliability concern, and is an actual cost concern.

- Outage concerns exist regarding excessive salt build up on the insulator strings for a line this close to ocean. This can cause flashovers and potential outages. Again, the remoteness of this area of the line makes it difficult to access structures frequently where salt needs to be washed from the insulators. Insulator washing is common with ocean side transmission lines, when accessible. According to NP-LH-097, the 66 kV line in the same area has much longer insulator lengths than a normal 66 kV line. It is assumed this additional length is to provide improved flashover performance when salt builds up and cannot be washed as frequently as required.

  > *"HVDC requires special care in string design and insulator selection: attention must be paid to the materials being used, the specific stress conditions on the dielectric but also the metal end fittings design…."* (CIGRE 2009)

- According to the answer to RFI CA-NLH-141, "Conductors, insulators, and hardware have been designed to withstand loads greater than structures, and will withstand loads beyond those depicted in Hydro's response to NP-NLH-004, and therefore beyond the return periods as presented." Based on this response, the next question would be, "How much greater are these design loads than the structure loads?" The increase in return period cannot be determined or justified by this statement.

- The basic ground clearance is 8.3 m (27 ft.) for ±320 kV HVdc. This ground clearance used in this design is the bare minimum, as noted by IEC or CSA code. Bare minimum in this context is what is deemed "pedestrian clearance" in the NESC code in the USA. The use of pedestrian clearance is not typically used for the design of new high voltage overhead transmission lines in North America even if the terrain can logically be traversed only by pedestrians. New lines are most typically designed for what is called “Vehicle Clearance” which is higher from the ground than pedestrian clearance. In addition, the electrical transfer capacity of this 320 kV HVdc line is similar to a 500 kV AC line. It’s our opinion that the ground clearance should be equivalent or higher than what is required for a 500 kV AC line.

CONCLUSIONS AND RECOMMENDATIONS

- A risk assessment of transmission overhead line reliability cannot be performed with available documents and current RFI responses.

- Long-distance high-voltage electrical transmission lines need to be designed to a higher reliability and lower risk level. Since the electric transfer capacity of the 320 kV HVdc LILTL line is similar to a 500 kV AC line, it is recommended the reliability should be in line with said 500 kV AC line.

- It is recommended that an “as-built” risk/reliability assessment be performed after construction to find potential mechanical weak points.

APPENDIX A

RICHARD N. COLLINS, PE

Vice President/Manager, Transmission Line Engineering

QUALIFICATIONS SUMMARY

Mr. Collins has more than 25 years of professional engineering experience relating to the design of high-voltage electric transmission lines. His experience ranges from 23 kV through 500 kV with projects covering line refurbishments, thermal upgrades, reconductoring, voltage upgrades, and new facilities. He has extensive experience in many types of foundation designs and has over 10 years of project management experience. As department manager, he oversees staff of 60+ professionals engaged in the design of transmission lines and is responsible for overall quality assurance of the department's output, staff development, and resource management. He chaired the *Line Design Working Group* within IEEE for several years and is currently the sub-committee chair for the *Overhead Lines* sub-committee within the *IEEE Power Engineering Society*.

EMPLOYMENT HISTORY

1991-Present	Commonwealth Associates, Inc., Jackson, Michigan
1984-1991	SSOE Inc., Flint, Michigan

REPRESENTATIVE EXPERIENCE

National Grid: Project Manager for 24 transmission line projects for from 2007 through 2010. Projects ranged from 69 kV to 230 kV refurbishments to new transmission lines. Also developed and taught a course on transmission line design multiple times for new hires at National Grid.

Consumers Energy Company: Participated in routing, foundation design, and site inspection for a 60-mile 345 kV line in Michigan.

New England Global Transmission Company: Prepared Engineer-Procure-Construct (EPC) transmission line specifications and cost estimates for 500 kV lines in South America. Also developed preliminary design and cost estimates for comparing a 500 kV AC versus a ±450 kV DC line in Australia.

International Transmission Company: Project Engineer for a 33-mile double-circuit 230 kV line in Michigan. Steel poles were designed to replace an existing 120 kV wood H-frame line.

AES Corporation: Foundation Design Engineer for a 230/115 kV overhead line project. Most of the drilled pier foundations were set in rock. Blasting with dynamite created a need for continual coordination with the contractor during construction.

Bangor Hydro-Electric Company: Project Manager for engineering of the 84-mile 345 kV Northeast Reliability Interconnect to New Brunswick. The line is supported on predominantly wood H-frame structures with tubular steel dead ends.

PG&E (NEG): Project Manager for a 13-mile 230 kV transmission line turnkey project in California. The project used double-circuit steel poles and bundled 2156 kcmil Bluebird conductor to connect an existing substation to an IPP power plant.

Conectiv Energy: Project Manager for a 5-mile 230 kV transmission line in New Jersey. The line used bundled 2493 kcmil ACAR conductors supported by steel poles on caisson foundations.

Rochester Gas and Electric Corporation: Project Manager for routing, design, and material procurement for a 7-mile 115 kV line in New York. The project involved building over existing 34.5 kV and 12 kV lines through an existing congested urban and industrial corridor. The line was supported on a combination of wood poles (self-supporting and guyed), steel poles, and lattice towers and crossed one major highway, the Erie Canal, and several railroads. It was also necessary to reroute two 1/4-mile sections of a 115 kV line through existing substations using steel poles. Over 50 percent of the steel pole foundations had to be designed for installation into bedrock. This project also included two short segments of 115 kV solid dielectric underground cable.

New England Power Service Company: Conducted a field inspection and prepared a report detailing different repair alternatives for two severely deteriorated concrete foundations built in the 1930s to support lattice towers at the base of a hydro-electric dam on the Connecticut River in New Hampshire.

EDUCATION

BS, Civil Engineering, University of Michigan, 1984

Additional Training

Dale Carnegie Training Course, 2012

Business Acumen for High Potential Executives, Ross School of Business, Univ. of Michigan 2015

REGISTRATION

Professional Engineer in Alabama, Arkansas, Florida, Georgia, Illinois, Kansas, Maine, Maryland, Massachusetts, Michigan, New York, Oklahoma, Rhode Island, South Carolina, Tennessee, Texas and Virginia

Professional (Civil) Engineer in California and Vermont

PROFESSIONAL AFFILIATIONS

National Society of Professional Engineers

American Society of Civil Engineers

IEEE, Power Engineering Society - Towers, Poles and Conductors Subcommittee, Working Group Chair – Line Design Methods, 2006-2011

IEEE Power Engineering Society, Overhead Lines Subcommittee Chair, 2011-Present

PUBLICATIONS

"Interfacing with Structure Modules", presented at the PLS-CADD Users Group Meeting, Jackson, Michigan. October, 1998.

"*Bridge Optimization Using WIRELDS and MINDES for the Marketplace-Mead-Westwing 500 kV Transmission Line Lattice Tower Design*", presented at the Electrical Power Research Institute Midwest Users Group Meeting, Jackson, Michigan. July, 1992.

YAIR BERENSTEIN, P.ENG
Senior Engineer

QUALIFICATIONS SUMMARY

Mr. Berenstein has over 27 years of experience in project management, transmission line engineering and design, rerating, sag measurements and analysis, inspections and engineering construction plans, line optimization, conductor selection and structural analysis. He has engineered numerous 11 kV to 765 kV line projects for major utilities in the United States and abroad. He has created and developed specialized software that has led to lowering construction costs and aided in determining sag tensions and loads on structures. He is proficient in Project Engineering and Advanced Mathematics.

EMPLOYMENT HISTORY

2013-Present	Commonwealth Associates, Inc., Liberty Lake, Washington
2010-2013	Trimble Navigation Limited, Liberty Lake, Washington
2004-2010	Owner, Pondera Engineers, LLC, Spokane, Washington
2002-2004	Itron, Inc., Liberty Lake, Washington
1997-2002	LineSoft Company, Spokane, Washington
1988-1997	Israel Electric Company Ltd., Israel
1987-1988	Israel Aircraft Industrial, Israel

REPRESENTATIVE PROJECTS

Commonwealth Associates:

Duke Energy Florida: Developed design criteria and a remediation process for the analysis and repair of existing Strain Bus structures for hurricane "hardening" of the strain structures. This was required for substation upgrades where conductors had been replaced with twin 795 AAC conductors and the wind velocity has been increases to 135mph between several existing 35-ft and 42-ft structures.

Okanogan PUD: Project Principal Engineer responsible for Transmission Line Design Services for the designed rebuilding of three lines totaling 56 miles of 115kV transmission line. The existing single pole and H-Frame wood pole lines will be reconstructed of single, ductile iron poles and/or H-Frame ductile iron poles and the existing copper conductor replaced with 556MCM "Dove" ACSR.

M&S Engineers: Performed a sag tension investigative study of eight (8) different ruling spans (herein 8RS) of 556MCM "Dove" ACSR type T-2 conductor using both SouthWire Sag10™ software and PLSCADD™ software to verify the design tension limits on a recently constructed single circuit. The tension limits were then compared them to the CIGRE method for establishing recommended design tensions to minimize Aeolian Vibration without dampening.

Barnard Construction Company: Performed a review of bid design and final design documents for a lattice steel tower family of double circuit 230kV transmission towers for a General Contractor. This was part of an investigation into why the final tower design weights had been in extreme excess of the original, preliminary design weights used in the project bid.

Avista-Ross Park-3rd & Hatch Line, Martin Luther King Jr. Blvd Extension: Performed a deep pile foundation design for 115kV steel Poles using MFAD.

Trimble Navigation Limited: Software Sales Manager responsible for ensuring technical support of Trimble software to meet client needs. Analyzed proposals and related technical data to determine feasibility, expected effort, strategic opportunities, risks and contingencies and business implications. Directed engineering support staff, provided technical support for engineers and technicians, developed software tools for design, analysis, installation and testing, project management and training of internal and external customers.

Enbridge: Served as Project Principal Engineer for the design of 214 miles of the MATL 230 kV transmission line from Great Falls, Montana, to Lethbridge, Alberta, Canada. This complex project involved design and testing of 160' tubular steel monopoles being used on approximately 105 miles of the project. Three tubular steel structure types were full-scale tested to 110% of NESC medium loading. Actual deflections versus calculated deflection comparisons were performed. Actual guy tensions were measured and compared to calculated tensions. The project also included approximately 77 miles of wood pole H-frame structures and 32 miles of light-duty steel monopole structures. Materials specification and testing was a major portion of the work, as well as landowner and permit mitigation and coordination with other MATL project team members.

Reliance Energy, India: Developed design criteria for the design of structure tower families for double-circuit 400 kV and single-circuit 765 kV transmission lines. Created load trees based on Indian transmission line standards in conjunction with concept layout design of the towers. Modeled, designed and optimized tower members in PLS-Tower. Provided detail drawings for joint design and subsequent manufacturing. Developed Foundation designs using PLS-Tower to determine ground line reactions and included a grillage foundation and a multiple concrete foundation options for various soil types.

Salt River Project: Technical Advisor for a re-rating project involving 156 miles of 230 kV transmission lines and 34 miles of 500 kV lines. Work included LiDAR survey, building a 3D model of the existing lines, determining the rating temperature after conductor temperature checks, determining clearance violations at 120, 167 and 212 degrees Fahrenheit and providing estimates for uprating each line.

Salt River Project: Project Engineer responsible for rerating 17.2 miles of the Goldfield-Queen Valley 230 kV wood H-frame line, 18.3 miles of the Queen Valley-Silverking 230 kV lattice tower line, and 10.5 miles of the Westwing-Deer Valley 230 kV lattice tower line. Tasks included surveying, sag measurements, high-temperature conductor calculations, clearance analysis, rerating analysis (with and without conductor bundling) and rerating recommendations resulting in structure replacement. Maximum operating temperatures were increased from 167°F to 221°F.

Montana Power: Project Manager for reconductoring the 133-mile, 100 kV Rainbow-Canyon Ferry Taps lattice tower line in mountainous terrain of western Montana. The project included helicopter laser surveying to collect profile and conductor data, detailed structural inspection and field inventory of 1,300 lattice and wood structures, climbing inspection of selected structures, building a complete computer model, clearance analysis of the existing conductor, strength analysis and insulator swing analysis. Completed detailed construction plans and engineering analysis.

Israel Electric Company: Senior Principal Engineer of Development Network-Overhead Lines responsible for design, analysis, and full-scale testing of lattice and tubular steel 161 kV and 400 kV transmission structures. Provided technical support for all engineers and technicians. Developed standard loading criteria, safety factors, design and analysis procedures, material specifications and material testing procedures for high- and low-voltage lines. Developed software tools for design, analysis, and installation and testing of structures and conductors.

EDUCATION

MS, Civil Engineering, Israel Institute of Technology, 1995
BS, Civil Engineering, Israel Institute of Technology, 1986

REGISTRATION

Professional Engineer, State of Israel
P.Eng, Alberta, Newfoundland & Labrador, Canada

PROFESSIONAL AFFILIATIONS

ASCE/SEI Technical Activities Division Committee creating the *Manual of Practice on Guidelines for Wood Pole Structures for Electrical Transmission Lines and* Committee on ASCE-Manual No. 74 "Guidelines for Electrical Transmission Line Structural Loading", 4th Edition.
IEEE/PES
F.ASCE/SEI
(Former Member) CIGRE/WG12

APPENDIX B

Exhibits			**Others Documents**		
Name	Date	by	Name	Date	by
Muskrat Falls Project - Exhibit 48	June 12 1981	Power Technologies, Inc. Schenectady, New York	Review of the Muskrat Falls and Labrador Island HVdc Link and the Isolated Island Options	October 2012	Manitoba Hydro International
Exhibit 85-Reliability Study of Transmission Lines of the Avalon and Connaigre Peninsulas	April, 1996	TRO Engineering	Emera Newfoundland and Labrador Maritime Link Project, Engineering Review of the Project	January 26, 2013	Hatch
Muskrat Falls Project - Exhibit 90, Newfoundland and Labrador Hydro's Wind and Ice Load Monitoring Test Facility	Spring-Summer 1994	IEEE	Upgrade Transmission Line Corridor - Bay d'Espoir to Western Avalon	September 2011	Nalcor Energy
Exhibit 92-The Lower Churchill Project, DC1070-Preliminary Meteorological Load Review	August 2008	Hatch/RSW/Statnett/TGS	The Maritime Link Transmission Project:	November 2011	Emera Newfoundland & Labrador
Exhibit95- Evaluation of in cloud icing in the Long Range Mountain Ridge	December 2010	Landsvirkjun Power/EFLA Engineering/ S.M. Fikke Meteorological Consultant	The-Liberty-Consulting-Group-Newfound-Power-Report-12-17-2014.pdf	December 2014	The Liberty Consulting Group
Exhibit96- Evaluate extreme ice from freezing rain for Newfoundland and Labrador Hydro	January 2010	Kathleen F. Jones Terrestrial and Cryospheric Sciences Branch Cold Regions Research and Engineering Laboratory Hanover, New Hampshire	The_Liberty_Consulting_Group_Hydro_Report_12_17_2014_32413.pdf	December 2014	The Liberty Consulting Group

Exhibits			**Others Documents**		
Name	Date	by	Name	Date	by
Exhibit 97-Review of Existing Meteorological Studies Conducted on the Labrador – Island Transmission Line, Nalcor Energy – Lower Churchill Project	September 2011	Nalcor Energy	Lower-Churchill-Project-July-2014-IE-Site-Visit-issued-Oct-2014.pdf	December 2014	The Liberty Consulting Group
Exhibit 97 Appendix A Rev. 1 27932	March 9 2012	Nalcor Energy	Lower-Churchill-Project-November-2014-IE-Site-Visit-Report.pdf	November 2014	Newfoundland Power Inc.
Exhibit 105 Transmission Planning Manual, System Planning Department	September 2008, Rev. 2	Nalcor Energy	NP-Application-to-Order-Hrydro-to-File-Full-Responses-2015-03-20.pdf	March 2015	Newfoundland Power, Inc.
Muskrat Falls Project - Exhibit 106, Technical Note Labrador — Island HVdc Link and Island Interconnected System Reliability	Oct-11	Nalcor Energy	pu13-2015	May 2015	Newfoundland and Labrador Board of Commissioners of Public Utilities
Muskrat Falls Project - Exhibit 114, Upgrade Transmission Line Corridor, Bay d'Espoir to Western Avalon	September 2011	Nalcor Energy	MHI_Report_VolumeII_23749	January 2012	Manitoba Hydro International

Exhibits			Others Documents		
Name	Date	by	Name	Date	by
			The Liberty Consulting Group - Phase Two Report	August 19, 2016	The Liberty Consulting Group
			Island Interconnected System - Phase Two - Teshmont Report and Risk Assessment - Final	May 5, 2016	Newfoundland Hydro

Consumer Advocate	Grand Riverkeeper Labrador	Newfoundland Power		Public Utilities Board	Newfoundland and Labrador Hydro
CA-NLH-036.pdf	files_rfi_GRK-NLH-093-GRK-NLH-133.pdf	NP-NLH-001.pdf	NP-NLH-066.pdf	PUB-NLH-212.pdf	NLH-PUB-001.pdf
CA-NLH-037.pdf	GRK-NLH-033.pdf	NP-NLH-004.pdf	NP-NLH-066.pdf	PUB-NLH-221.pdf	NLH-PUB-002.pdf
CA-NLH-039.pdf	GRK-NLH-038.pdf	NP-NLH-005 Rev 1.pdf	NP-NLH-067.pdf	PUB-NLH-231.pdf	NLH-PUB-003.pdf
CA-NLH-054.pdf	GRK-NLH-038-Rev1.pdf	NP-NLH-006.pdf	NP-NLH-067.pdf	PUB-NLH-232.pdf	NLH-PUB-004.pdf
CA-NLH-086.pdf	GRK-NLH-045-Rev-1.pdf	NP-NLH-007.pdf	NP-NLH-068.pdf	PUB-NLH-240.pdf	NLH-PUB-005.pdf
CA-NLH-086-CA-NLH-131.pdf	GRK-NLH-057-Rev-1.pdf	NP-NLH-008.pdf	NP-NLH-068.pdf	PUB-NLH-266.pdf	NLH-PUB-006.pdf
CA-NLH-84-CA-NLH-85.pdf	GRK-NLH-060.pdf	NP-NLH-009.pdf	NP-NLH-069.pdf	PUB-NLH-268.pdf	NLH-PUB-007.pdf
CA-NLH-087.pdf	GRK-NLH-066.pdf	NP-NLH-010.pdf	NP-NLH-069.pdf	PUB-NLH-269.pdf	NLH-PUB-008.pdf
CA-NLH-088.pdf	GRK-NLH-066-Rev-1.pdf	NP-NLH-012.pdf	NP-NLH-070.pdf	PUB-NLH-270.pdf	
CA-NLH-089.pdf	GRK-NLH-069-Rev-1.pdf	NP-NLH-018 Rev 1.pdf	NP-NLH-070.pdf	PUB-NLH-274.pdf	
CA-NLH-089.pdf	GRK-NLH-074-Rev-1.pdf	NP-NLH-020.pdf	NP-NLH-071.pdf	PUB-NLH-298.pdf	
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CA-NLH-095.pdf	GRK-NLH-098.pdf	NP-NLH-037.pdf	NP-NLH-074.pdf	PUB-NLH-502.pdf	
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CA-NLH-097.pdf	GRK-NLH-100.pdf	NP-NLH-038.pdf	NP-NLH-075.pdf	PUB-NLH-533.pdf	
CA-NLH-097.pdf	GRK-NLH-101.pdf	NP-NLH-038.pdf	NP-NLH-076.pdf	PUB-NLH-534.pdf	
CA-NLH-098.pdf	GRK-NLH-102.pdf	NP-NLH-039.pdf	NP-NLH-076.pdf	PUB-NLH-535.pdf	
CA-NLH-099.pdf	GRK-NLH-103.pdf	NP-NLH-040.pdf	NP-NLH-077.pdf	PUB-NLH-536.pdf	
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CA-NLH-101.pdf	GRK-NLH-107.pdf	NP-NLH-042.pdf	NP-NLH-079.pdf	PUB-NLH-540.pdf	
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CA-NLH-117.pdf	GRK-NLH-127.pdf	NP-NLH-053.pdf	NP-NLH-089.pdf	PUB-NLH-560.pdf	
CA-NLH-118.pdf	GRK-NLH-128.pdf	NP-NLH-053.pdf	NP-NLH-090.pdf	PUB-NLH-561.pdf	
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CA-NLH-126.pdf		NP-NLH-058.pdf	NP-NLH-101.pdf	PUB-NLH-570.pdf	
CA-NLH-127.pdf		NP-NLH-058.pdf	NP-NLH-102.pdf	PUB-NLH-571.pdf	
CA-NLH-128.pdf		NP-NLH-059.pdf	NP-NLH-103.pdf	PUB-NLH-572.pdf	
CA-NLH-129.pdf		NP-NLH-059.pdf	NP-NLH-94.pdf	PUB-NLH-573.pdf	
CA-NLH-130.pdf		NP-NLH-060.pdf	NP-NLH-95.pdf	PUB-NLH-574.pdf	
CA-NLH-131.pdf		NP-NLH-060.pdf	NP-NLH-96.pdf	PUB-NLH-575.pdf	
CA-NLH-132.pdf		NP-NLH-061.pdf	NP-NLH-97.pdf	PUB-NLH-576.pdf	
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CA-NLH-134.pdf		NP-NLH-062.pdf	NP-NLH-99.pdf	PUB-NLH-578.pdf	
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CA-NLH-136.pdf		NP-NLH-063.pdf	NP-NLH-113.pdf	PUB-NLH-580.pdf	
CA-NLH-137.pdf		NP-NLH-064.pdf	NP-NLH-122.pdf	PUB-NLH-581.pdf	
CA-NLH-138.pdf		NP-NLH-064.pdf	NP-NLH-123.pdf	PUB-NLH-583.pdf	
CA-NLH-139.pdf		NP-NLH-065.pdf	NP-NLH-134.pdf	PUB-NLH-584.pdf	
CA-NLH-140.pdf		NP-NLH-065.pdf	NP-NLH-147.pdf	PUB-NLH-585.pdf	
CA-NLH-142.pdf				PUB-NLH-586.pdf	
CA-NLH-141.pdf		NP-PUB-001.pdf - NP-PUB-026.pdf		PUB-NLH-587.pdf	
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CA-NLH-150.pdf				PUB-NLH-591.pdf	
CA-NLH-151.pdf				PUB-NLH-592.pdf	
CA-NLH-152.pdf				PUB-NLH-593.pdf	
CA-NLH-155.pdf				PUB-NLH-594.pdf	
CA-NLH-162.pdf					
CA-PUB-034.pdf - CA-PUB-051.pdf				IC-PUB-001 to IC-PUB-034.pdf	
				NLH-PUB-001 to NLH-PUB-008	