STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION

and

STATE OF MAINE
LAND USE PLANNING COMMISSION

IN THE MATTER OF

CENTRAL MAINE POWER COMPANY)
NEW ENGLAND CLEAN ENERGY CONNECT)
#L-27625-26-A-N/#L-27625-TG-B-N/)
#L-27625-2C-C-N/#L-27625-VP-D-N/)
#L-27625-IW-E-N)

CENTRAL MAINE POWER COMPANY)
NEW ENGLAND CLEAN ENERGY CONNECT)
SITE LAW CERTIFICATION SLC-9)
Beattie Twp, Lowelltown Twp, Skinner Twp,)
Appleton Twp, T5 R7 BKP WKR,)
Hobbstown Twp, Bradstreet Twp,)
Parlin Pond Twp, West Forks Plt, Moxie Gore,)
The Forks Plt, Bald Mountain Twp, Concord Twp)

Pre-Filed Sur-Rebuttal Testimony of Gil A. Paquette on behalf of Group 3

April 19, 2019

A. Introduction and Qualifications

My name is Gil A. Paquette. I am a Managing Director and head of the Energy and Environmental Practice at Vanasse Hangen Brustlin, Inc. located at 500 Southborough Drive, South Portland, Maine. I received a BS degree from the University of Maine in Wildlife Management and an MS degree from the University of Western Ontario in Zoology. I have 23 years of experience working on a variety of energy projects including natural gas pipelines, electric transmission lines (both overhead and underground), hydro-electric relicensing, wind power, and solar power. My CV is attached hereto as "Exhibit Group 3 Sur-rebuttal 1." A list of Representative project experience is attached hereto as "Exhibit Group 3 Sur-rebuttal 2."

The primary focus of my consulting is in the areas of stakeholder management, siting, permitting, and construction management of large energy infrastructure, most notably electric transmission lines. I have advised clients on strategic siting issues related to avoiding, minimizing, and mitigating impacts to natural resources. My advice with respect to siting and designing a transmission line is based on a holistic approach, considering input from a variety of stakeholders to balance both societal and natural resource concerns.

I use my skillset and substantial experience to manage and coordinate multi-disciplinary teams on projects that require integration of stakeholder outreach, design, permitting, cost-estimating, materials procurement, and construction. I have worked on many projects from inception to completion. From my 23 years of experience, I have developed an intricate understanding of all aspects of electrical energy infrastructure projects, both large and small, including, as relevant to this Project:

- Project siting;
- Stakeholder management;
- Preparation of RFPs for materials and contractors;
- Cost estimating;
- Preparation of feasibility studies;
- Technology research;
- Preparation of recommendation documents for materials and contractor selection;
- Permitting;
- Construction management;
- Managing alternating current ("AC") mitigation studies/design/construction;
- Managing electrical, structural, and civil design and studies;
- Preparation of vegetation management plans;
- Preparation of erosion and sedimentation control plans; and
- Managing large teams for natural and cultural resource studies and engineering.

More specifically, I have worked extensively on the development of two high voltage direct current ("HVDC") electric transmission projects. The first project was the Northeast Energy Link, a proposed 230-mile underground HVDC cable from Orrington, Maine to Tewksbury, Massachusetts. Initially, I was retained by Bangor Hydro (then Emera Maine) to conduct a routing feasibility study of several routes, including terrestrial and submarine. Later, I was asked by Emera Maine to act as overall Project Manager. In that role, I worked with cable manufacturers and contractors to develop a detailed cost estimate to construct the project. For a variety of reasons, the project did not advance beyond the development stage, but my experience with assessing various routes, managing the project, and dealing with cable manufacturers and contractors on cost issues has given me expert knowledge on the use of HVDC technologies in Maine.

The second project was the Atlantic Link proposed by Emera Inc. Atlantic Link was a proposed 375-mile HDVC submarine cable from Coleson Cove, New Brunswick to Plymouth, Massachusetts. I was retained by Emera Inc. as the permitting lead for U.S. facilities and to support siting, the stakeholder team, and surveys. Atlantic Link submitted a response to the Massachusetts Section 83D RFP but was not selected. Despite the project's status on hold, my experience as permitting lead deepened my knowledge of HVDC technologies, and especially cost implications related to logistics.

B. Purpose and Overview of Testimony

I am testifying on behalf of Intervenor Group 3 to rebut certain testimony of the Applicant related to undergrounding the New England Clean Energy Connect Project ("NECEC" or "Project") and to clarify for the Department of Environmental Protection and the Land Use Planning Commission additional technical information highly relevant to the practicability, suitability, and environmental impacts of undergrounding the Project that was overlooked or underestimated in the rebuttal testimony of Mr. Bardwell.

Having prepared site-specific routing analysis and cost-estimates for similar projects, I have learned that many logistical aspects of underground transmission line installation are often oversimplified and overlooked by design engineers. It is only through thorough research and an understanding of the site-specific implications of installing HVDC cable underground along the entire route that the logistical complications and the environmental impacts can be fully understood. However, it is also true that certain complications can arise initially, generally, or with respect to natural resources in specific locations, that would preclude undergrounding as a viable alternative to an overhead line.

In this case, CMP was correct in not initially considering an underground alternative for Segment 1 from a legal perspective, i.e., doing a full-blown regulatory alternatives analysis, because based on initial engineering considerations it could reasonably be determined that undergrounding would not work for myriad reasons associated with practicability, including cost, transportation logistics, and construction challenges, many of which would increase negative environmental impacts compared to an overhead line. One of the most important criteria in determining the ability to install an HVDC cable underground is location. Segment 1's relative remoteness, topography, geology, hydrology, and long stretches of ROW between access points make it inherently unsuitable for burying an HVDC cable. Engineering and other power line construction professionals are or should be aware of these factors, especially as they present in Segment 1, and would not want to invest scarce time, money, and resources in analyzing a fruitless option.

In response to Project opponents' testimony, however, CMP specifically identified many reasons related to the impracticability of undergrounding in its sur-rebuttal testimonies by Mr. Dickinson, Mr. Tribbet, and Mr. Bardwell. These witnesses provided detailed analysis beyond what was initially necessary to make a practicability determination, though overlooking and understating many logistical challenges and the associated environmental impacts of undergrounding. For example, CMP overlooked or understated challenges with mobilization of cable, thermal sand, and equipment along a remote ROW, as well as some of the difficulties associated with splicing relatively short lengths of cable along a remote ROW, protecting those splices with concrete, and ensuring reliable and efficient operation of an underground cable going forward. While I agree with the general conclusions of CMP's rebuttal testimony, at least directionally as they relate to cost and environmental impacts, the testimony failed to consider the full cost and environmental implications associated with many logistical aspects to undergrounding a transmission line that, in my experience, have been determinative of whether undergrounding is practicable, less environmentally damaging, suitable to the proposed use, and reasonably available to the Applicant.

Based on my experience, although an underground transmission line compared to overhead may intuitively seem appealing from the perspective of minimizing environmental impacts, there are in fact far greater environmental impacts from undergrounding, especially to streams, rivers, wetlands and other protected and sensitive natural resources. Undergrounding may appear simple but is often extremely complex and challenging. The following testimony describes the differences in access, logistics, constructability and associated environmental impacts between an underground cable and an overhead conductor, with consideration of the remote setting of Segment 1, where an underground alternative has been suggested by Project opponents.

C. Background and Assumptions

For simplicity, it is important to note initially that the “lines” involved in an underground electric transmission line are called cables, whereas the “lines” in an overhead electric transmission line are called conductors. Reference to “cable” in my testimony shall be in the context of constructing an electric transmission line underground. Reference to “conductor” shall be in the context of constructing an electric transmission line aboveground.

My testimony assumes a polymeric insulated (“PE”) HVDC cable design as opposed to a mass-impregnated non-draining (“MIND”) HVDC cable to address the undergrounding alternative. It is important to note that because PE cable technology was developed in the late 1990’s, to my knowledge, long-term data on the life of the cable and cable splices is not available. I have also assumed that the lifespan of the Project is at least 40 years, which if true for other PE projects means that no PE project has yet to operate for the entirety of its useful life at the proposed voltage of the NECEC.

MIND HVDC cables have been used for long-distance, submarine transmission systems for more than 50 years. The electrical insulation system in MIND cables typically consists of (i) a semi-conducting carbon paper layer around the surface of the cable, (ii) a main insulation layer consisting of vacuum-dried paper impregnated with high-viscosity, insulating oil, and (iii) an outer conductive layer consisting of carbon- and metal-laminated paper. A hermetically-sealed lead sheath with a polyethylene jacket protects the insulation from moisture or water penetration, layers of galvanized steel tape and steel wire provide the required mechanical strength, and an outer layer of bitumen-bonded polypropylene yarn provides corrosion protection to the cable armoring.

Even though MIND cables have been extensively used in long-distance, submarine transmission systems in North America, Europe, New Zealand, Australia, the Philippines, and the Far East, there are few examples of MIND cable installations over any significant distance underground. One of the principal reasons is that MIND cables are challenging and costly to splice and, therefore, are difficult to install unless the cable can be transported from the factory to the installation site in long, continuous lengths on either a turntable or very large steel drums. Transportation of turntables or very large steel drums to an inland site by railroad or public roadways, on the other hand, is generally impractical, if not impossible, due to transport width, height, and weight restrictions.

In some of the few locations where MIND cable circuits were installed underground over significant distance, field splices were avoided by bringing the cable on-shore in long continuous lengths from an off-shore installation vessel. Such off-shore vessels are obviously unavailable for long-distance terrestrial projects. For example, a relatively short 3.3-mile-long underground section on the Swedish side of the 450 kV, 600 MW, Baltic cable system between Sweden and northern Germany was laid in one continuous length in an open cut trench from the shore landing site to the HVDC converter station. (On the German side, the cable was installed in the Trave River up to the location of the HVDC converter station near the City of Lübeck.)

Including to overcome the challenges and limitations of MIND cables in connection with long-distance underground transmission, cable manufactures developed and introduced the PE HVDC cable design in the late 1990’s. The insulation system in PE cable consists of a semi-conducting poly-ethylene conductor screen, a main insulation layer, and a semi-conducting poly-ethylene insulation screen. The insulation system is manufactured in a true triple-extrusion process in a continuous vulcanization line. PE cables can be laid in an open cut trench (direct burial) or pulled through conduits in horizontal directional drillings (“HDD”) or duct-bank systems. Tape joints are used for splices. The joints are similar to pre-molded cable joints used for ±320 kV AC cross-linked PE cable circuits.

With the development of this new PE technology, terrestrial undergrounding of HVDC cable is now more cost-effective and eliminates the environmental issues associated with oil-filled cables. Additionally, paper-oil insulated cables have a rather complex and expensive manufacturing process. PE cables can offer significant advantages when compared to MIND cables, including: a higher conductor temperature for the same power rating; utilization of lighter moisture barriers, thus reducing weight; a simpler splicing process; utilization of longer lengths of cable; and generally reduced maintenance requirements. Although there tends to be agreement in the field regarding these benefits, it is my understanding that no PE project has operated for the entirety of its useful life at the proposed voltage of the NECEC.

D. Drawbacks to Installing an HVDC Underground Cable in Segment 1

The technology exists to underground an HVDC cable. However, the specific issue in this case, as addressed below and as not sufficiently addressed in the Applicant's rebuttal testimony, is whether installing an underground cable in a remote part of Western Maine with undulating topography is a less environmentally damaging practicable alternative to overhead conductor or is suitable to the proposed use and reasonably available to the Applicant.

Despite the fact that Segment 1 is traversed by hundreds of miles of logging roads, mobilization of materials and equipment, as well as construction specifically used for burying an HVDC cable, would be extremely difficult, if not impossible, in some locations. I was not surprised to learn that CMP did not initially evaluate an underground option for Segment 1 given the much greater costs, the numerous challenges associated with burying an HVDC line in the proposed corridor, and the significant environmental impacts associated with construction and maintenance of an HVDC line. To many in the transmission field, not burying the NECEC would be an obvious conclusion given the Project setting. Through my work and research on other HVDC projects I have compiled a list of often-overlooked issues with respect to undergrounding that illustrates why undergrounding Segment 1 was not initially considered, and that reinforces that such option is not practicable, suitable, or reasonably available to the Applicant.

1. Costs

It is widely known in the industry that the costs of cable far exceed the costs of conductor. However, the intent of this testimony is not to reiterate this cost premium, but to describe the difficulty, overlooked or underestimated by Mr. Bardwell, in obtaining and installing a cable in general and in the context of Segment 1.

PE cable itself is specialized. There are limited PE cable production facilities in the world, as the demand for such cable in long lengths is relatively low when compared to conductor. Thus, PE cable acquisition lead times are long, and scheduling can be a serious constraint. As HVDC cables were originally designed for specific undersea projects, they have typically been fabricated in one continuous length (up to 70 miles), which is made feasible by the fact that the cable is transported by a specialized cable-laying vessel carrying the cable on a large turntable and directly installed on the ocean floor. This process minimizes the number of cable splices that must be made but is unavailable for the remote terrestrial route of Segment 1. As such, the process for undergrounding the NECEC would be far more onerous with significantly higher costs. Even disregarding the cost differential between cable and conductor, installing an HVDC cable in Western Maine is not practicable, suitable, or less environmentally damaging than an overhead conductor.

2. Cable Transportation

On page 4 of his rebuttal testimony, Mr. Bardwell states: "The cables are limited to approximately 2,500-foot shipping lengths …" I believe that Mr. Bardwell is oversimplifying. Based on my experience, 2,500 feet is the maximum shipping length. As cable is very expensive, and to reduce waste, reels would need to be loaded with specified cable lengths to match exact splice locations. Therefore, simply ordering standard 2,500-foot length reels is not a practicable option. Shorter lengths, which would no doubt be required, would have a compounding effect on logistics and environmental impacts for cable transportation, mobilization to the trench, splicing, splice protection, and access to the Segment 1 ROW for each of the foregoing. Mr. Bardwell does not discuss such logistical challenges and their associated environmental implications; in my experience, such challenges can be determinative of whether a line can be buried. He also does not discuss the logistical differences and consequent environmental impacts between an underground line and an overhead line, which are important to consider when determining whether undergrounding might be an alternative less damaging to the environment.

Conductor used in both AC and DC applications is generally transported on large reels, with each reel containing approximately 10,000 feet of conductor, depending on its size. The conductor typically has an inner core of stranded steel for strength and an outer layer of stranded aluminum to conduct the electricity. On a recent overhead project, four reels constituted a typical load using a tractor trailer, with a total payload of approximately 40,000 feet of conductor. Based on these numbers, for Segment 1, an overhead project with 4 conductors (excluding fiberoptic) would require roughly 112 reels and 28 tractor trailer loads for conductor transportation.

Due to weight restrictions, HVDC cable, such as the one that would need to be used on the NECEC, can only be transported in approximately 2,000-foot to 2,500-foot lengths, depending on cable design. It is possible to transport up to four reels of cable on a tractor trailer, but such load would weigh between 55 and 75 tons and would therefore be difficult to transport on rough, uneven, or muddy logging roads and impossible on some logging road bridges. Based on specific project experience, my understanding is that only one reel can be transported per load due to weight restrictions on some highway bridges that act as binding constraints, despite the fact of other bridges being able to accommodate three reels. Conservatively assuming 2,000-foot lengths of cable rolled onto three reels per tractor trailer, transportation of HVDC cable to and on logging roads to the Project site would require over 6 times the amount of tractor trailers compared to using conductor. Based on these numbers, for Segment 1, undergrounding with five cables (including one spare cable and excluding fiberoptic) would require roughly 700 reels and 234 tractor trailer loads. Such increased heavy-duty traffic would cause greater damage to logging roads and could necessitate significant road and access improvements, thus increasing the threat to protected natural resources adjacent to the roads, including wetlands and waterbodies.

3. Trenching

To most cost-effectively install an HVDC cable, the direct burial method would be used, which would require an excavated trench approximately six feet deep along the entire Segment 1 right-of-way ("ROW"). Mr. Bardwell, on page 4 of his rebuttal testimony, states: "A typical trench would be approximately five feet wide at the bottom with sloping sides for a minimum surface width of 12 feet, increasing when trench depth increases." While this is generally true, Mr. Bardwell does not fully explain Occupational Safety and Health Administration ("OSHA") requirements and other variables affecting sloping. Per OSHA, the trench would need to be sloped on each side of the trench to protect workers. Sloping requirements depend on soil type, with greater sloping required for less stable soils and soils generally classified into three types based on their stability (A, B, and C). Assuming a five-foot width at the base of the trench to accommodate five cables, the width of the trench opening would range from an approximate minimum of 14 feet (with the most stable soil type, A) to an approximate maximum of 23 feet (with the least stable soil type, C). In my experience, the least stable soil type, C, occurs with some frequency in Maine. Soils that are less stable than C would require shoring the trench. With an overhead line, it is practicable to sample soils at the proposed location of tower structures and then make minor adjustments to avoid unstable soils. With an underground line, however, it is impracticable to sample soils for the entire length of the trench. Thus, unstable soils are generally unavoidable and can cause many unexpected delays when encountered.

Though sloping could be avoided in stable bedrock, it would be required through wetlands. An overhead transmission line would nearly always span wetland resources and thus avoid direct impacts. Even if a pole had to be placed in a wetland, the disturbance would be limited to a relatively minimal "point" as opposed to a linear disturbance. Undergrounding would also require trenching through streams, brooks, and even small rivers and other sensitive natural resource areas without use of HDD. Overhead structures, however, are never placed in streams, brooks and small rivers. Therefore, there would be far greater construction-related natural resource impacts from an underground project versus an overhead project.

Further, Mr. Bardwell states on page 4 of his rebuttal testimony that: "The cables are placed in a single row in a sand bedding layer approximately one foot deep in the bottom of the trench. Above the sand bedding layer a protective concrete slab would be poured and the trench above the slab would be backfilled with native soil." In my experience, a concrete slab is reasonable but not necessary, as underground warning tape could be used to detect where the buried cable exists under the surface. Additionally, Mr. Bardwell simply references "sand" and "native soil" backfill. I believe he overlooks the need for thermal sand as backfill (as I explain in section 8 below) and the logistical challenges presented by hauling thermal sand to backfill a linear trench that would span up to 53 miles.

4. Ledge

Mr. Bardwell does not sufficiently address the logistical challenges posed by ledge in his rebuttal testimony or compare the environmental impacts associated with ledge between an overhead and underground line. He states on page 14: "The most common risk for below grade construction is encountering bedrock shallower than expected. In areas with shallow bedrock, trenching would require blasting, hoe ram, or similar excavation methods." I agree that to install cable in ledge, the ledge would likely need to be blasted or hoe-rammed. Areas of blasting could extend for long distances, especially due to unforeseen bedrock conditions. However, there are other concerns that must be considered. For example, shot rock would need to be removed from the trench and either be exported off-site by heavy-duty dump truck or windrowed, as thermal sand is also required as trench backfill in bedrock.

Blasting may need to occur to allow for overhead transmission line structure placement, but these are in single-point locations, not along any great lengths, and can generally avoid sensitive areas like streams through structure placement and spanning. Blasting for direct burial of cable at stream and brook crossings would be generally unavoidable without the use of HDD. Such blasting would negatively impact the waterbodies themselves, as well as nearby flora and fauna. Therefore, ledge would cause greater construction-related impacts for an underground project than an overhead project.

5. Cable Mobilization for Installation

In his rebuttal testimony, Mr. Bardwell largely overlooks logistical complications associated with mobilizing cable for burial, especially compared to mobilizing conductor for installation. The logistical complications with undergrounding relate to cable being heavier and fabricated into shorter transportable lengths than conductor and result in additional costs and environmental impacts.

Both overhead AC and DC conductors are typically pulled from one location to another location around three miles away, depending on the type of conductor. As the reels typically contain 10,000 feet of wire, splices are used to create a continuous 3-mile (15,840-foot) length of conductor. The pulling and splicing process involves creating a location for the spools of conductor to be stored and eventually placed on a tensioner. At a second location, a puller would pull the conductor through blocks that are installed on the transmission line structures. The puller/tensioner sites are typically located where there is easy access to facilitate transporting the reels. In the Project setting, logging roads would likely be used to transport conductor to the puller/tensioner sites, which would be located immediately off logging roads in the project ROW. In my experience, sensitive natural resources are generally avoidable when establishing the puller/tensioner sites.

Just like an overhead conductor, an underground line must be spliced together from various reels of cable. But unlike conductor, cable cannot be pulled in a trench or on rollers, as the relatively weak splices would fail due to the weight of the cable. As such, cable reels would need to be mobilized to the location where the cable would be installed, in this case along the entire trenched ROW. Because of the weight of the reels, a significant number of mats would need to be placed along nearly the entire length of the ROW to allow for the transportation of the reels to the installation points. It is reasonable to assume that more environmental damage would be caused during this process when compared to conductor transportation, for which the conductor must only be transported to the puller/tension sites via an existing logging road.

In addition to mats, bridges would need to be installed at nearly every stream, brook, or small river crossing, and the bridges would need to be more robust than the typical temporary construction bridges that are installed at select locations for an overhead transmission line. With nearly every stream or brook requiring a bridge, undergrounding would create far greater impact to aquatic resources when compared to construction of an overhead transmission line.

While wetlands would be protected by mats for an underground line, two or three layers of mats may be needed to transport the cable reels due to the typical subsidence that occurs in wetlands when mats experience heavy loads and frequent traffic. Because of the excessive number of mats that would be required for an underground project, ground cover would likely become more denuded than for overhead construction and the restoration of both uplands and wetlands would be more challenging. It is therefore reasonable to assume that there would be more impacts to wetlands with an underground project compared to an overhead project.

6. Vaults

The weakest link of a cable is a splice. Because splices pose a reliability concern to the electric grid, each one must be protected by concrete vaults, which would also facilitate access to a splice that has failed. Mr. Bardwell, on page 4 of his rebuttal testimony, states: "Temporary structures would be erected over the jointing locations. Once the cables have been jointed, precast concrete enclosures approximately 12 feet long and 4 feet wide would be placed over each joint for additional protection and the jointing pit would be backfilled with sand and native soil." I believe Mr. Bardwell understates the size of the vaults that would be needed and overlooks the logistical challenges associated with transporting pre-cast concrete vaults.

The dimensions of vaults can vary depending on the project. Based on my experience, for the NECEC, the vaults would likely be around 26' x 8' x 8'. This size would require extensive excavating, significantly greater than that needed to install a pole. The excavation for the vaults would occur at approximately every 2,250 feet on average. If bedrock is present it will need to be blasted or hoe-rammed. Avoiding excavation for vaults in wetlands would likely be impossible.

I assume that the concrete vaults would need to be pre-cast, as it would be extremely challenging for concrete-mixing transport vehicles to access the Project ROW at each splice location. Similar to the reels, pre-cast concrete vaults would also need to be transported the length of the Project ROW for installation, necessitating the use of more or heavier-duty temporary facilities (e.g., mats) and possibly the construction and/or reinforcement of some permanent facilities (e.g., bridges). Restoration would be challenging as the topsoil and subsoil would need to be removed to accommodate the vault. Installing on slopes would also be challenging because it would be difficult to stabilize the excavated area on steep slopes.

Thus, the large vaults needed to protect cable splices would cause increased permanent and temporary environmental impacts relative to conductor, and many of those environmental impacts are unavoidable due to the linear nature of trenching.

7. Splices

Regarding splicing, Mr. Bardwell on page 4 of his rebuttal testimony estimates that an underground cable would need to be spliced approximately every 2,200 feet and would involve "weather- and humidity-controlled enclosures." While I generally agree with Mr. Bardwell, I believe that he overlooks the logistical complications associated with splicing in Western Maine. Further, Mr. Bardwell does not provide a comparison of the splicing requirements of an overhead line.

In addition to the need to travel the length of the ROW to transport cable and pre-cast concrete vaults, trailers would need to be transported to each splicing location along the Segment 1 ROW. The trailers are specifically designed for cable splicing, are temperature-controlled, and have a filter system for eliminating dust and other contaminants that could impact the splice. They can be thought of as mobile, sterile labs. There would be approximately 110 to 140 splice locations for Segment 1 assuming five cables (two per pole and one spare (excluding fiberoptic cables)) are installed along 53 miles of ROW and all cables can be spliced using one trailer location. For an overhead line, splices are installed in an open-air environment using a compression sleeve. Comparatively, there would be approximately 27 to 30 splice locations for an overhead line, which would also equate to 27 to 30 puller/tensioner sites. Thus, given the number of splicing locations (110-140), access requirements for those locations (e.g., roads, mats, bridges, etc.) and space and resource requirements needed for splicing trailers, the environmental impacts associated with an underground line are likely to be far greater than those of an overhead line.

8. Thermal Sand

As I previously stated, Mr. Bardwell does not discuss the need for thermal sand in his rebuttal testimony, and thus does not consider the logistical, environmental, and cost implications associated with thermal sand. In my experience, the need for, logistics concerning, and cost of thermal sand is the single most overlooked aspect of undergrounding an HVDC transmission line.

On a recent underground HVDC project I worked on, a major concern was the importation of thermal sand. For cables to operate efficiently and avoid hot spots that could lead to cable failure, the heat they necessarily create must be dissipated using thermal sand that surrounds the cables. Given the geology of Western Maine, with which I am familiar, it is likely that a majority of Segment 1 would require the use of thermal sand as backfill material. During the design phase, thermal resistivity measurements would need to be taken to determine if the native soil has the properties to allow for effective and adequate heat dissipation. Wetlands are particularly challenging because deep organic material does not dissipate heat well. Therefore, thermal sand would be required in all wetland trenches, impacting wetlands much more significantly than an overhead transmission line that would span the same wetlands.

Similar to transportation issues associated with reels, pre-cast concrete vaults, and splicing trailers, installing thermal sand would require extremely heavy dump trucks to travel nearly the entire length of ROW. While use of temporary mats and bridges are generally sufficient for typical overhead construction, in my experience, similar temporary facilities would not likely withstand the extensive, heavy-duty nature of vehicular traffic associated with properly constructing an underground HVDC line in Segment 1 using thermal sand where necessary. Thus, either much more extensive temporary or perhaps permanent facilities would be needed, which facilities would cause more environment impacts.

By way of example, for relatively lighter-duty construction and maintenance of overhead transmission lines, frozen ground and water can at times eliminate or reduce the need for mats and bridges. However, dump trucks containing thermal sand would still require the use of heavy-duty mats and bridges, even in winter. In addition to the issues described above, the thermal sand would displace the native material in the trench. Excess spoils would need to be spread on-site or hauled off-site, creating even more disturbance to natural resources and increasing the likelihood of erosion and sedimentation.

9. Replacing a Section of Damaged Cable

In his rebuttal testimony, Mr. Bardwell does not address the full scope of the logistical challenges and consequent environmental impacts with respect to addressing an operational failure associated with a splice or otherwise.

If damage occurs to a cable either at a splice or in another location, repairs or replacements would need to be conducted quickly to maintain electric reliability. A short length of new cable would need to be transported to the damaged cable location. Equipment would be required for excavating the damaged cable and a splicing trailer would be required as well. If the damaged cable is in a remote location, mats and bridges would need to be installed. There is a strong likelihood that the extent of mats and bridges would be much more extensive when compared to making repairs to an overhead line given the specialty equipment required to complete the repair, thus creating greater environmental damage and a longer window for restoration of power. To facilitate access for repairs, CMP may need to construct permanent access roads and bridges at select locations along the ROW, causing permanent damage to adjacent protected natural resources.

E. Conclusion

Undergrounding the NECEC within the 53 miles of Segment 1 is not practicable, suitable, or an alternative that is reasonably available to the Applicant. Further, undergrounding is not less environmentally damaging than an overhead transmission line. Thus, undergrounding is not an alternative to the NECEC that should have been or should be considered.

My conclusion is based on the physical characteristics of underground cable and my years of experience with the techniques required to transport, mobilize, install, splice, protect, repair, and replace it, as well as to ensure that it operates efficiently and reliably. In sum:

- Underground cable is specialized, heavier, and created in shorter lengths than overhead conductor for terrestrial application (≈ 2,000-2,500 feet underground versus 10,000 feet overhead)
- For Segment 1, more reels (≈ 700 underground versus 112 overhead) and trailer trucks (≈ 234 underground versus 28 overhead) would be required to transport underground cables than overhead conductor.
- Unlike overhead conductor, which can be pulled and tensioned from sites three miles apart, underground cable must be transported to the installation site (trench) spanning the entire ROW.
- With more reels and trucks for underground cable that must access the entire ROW, more mats and bridges, and perhaps some permanent improvements, would be needed than for an overhead line. More and better access roads would likely be needed due to heavier and more frequent traffic.

- Trenching six feet deep, five feet wide at the base, and between 14 feet and 23 feet wide at the opening would occur for 53 miles without interruption or the ability to avoid certain sensitive and protected resources. Testing of all soils along the ROW would not be practicable, so encountering unexpected instances or areas of unstable soils and ledge would add delay, costs, and additional logistical concerns.
- When trenching, ledge would need to be blasted or hoe-rammed wherever encountered.
- Thermal sand would likely be required along the majority of the Segment 1 ROW to backfill the cable trench, requiring excavation and removal of native soil, importation by dump truck of thermal sand, and thus heavy-duty temporary facilities (bridges and mats) or permanent facilities (bridges). Unlike with overhead conductor, sensitive (e.g., wetlands) and challenging (e.g. ledge) areas could not be avoided through structure placement and spanning.
- Splicing, requiring the use of specialized trailers, would occur along the entire ROW at about 140 locations, adding logistical concerns and environmental impacts relative to overhead conductor.
- At each splice, a permanent concrete vault (≈ 26'x 8'x 8') would need to be constructed for protection and access, often requiring a permanent access road.
- Repair or replacement of damaged cable or cable splices would cause extensive disruptions (e.g., heavy equipment, mats and bridges, excavating, splicing trailer, etc.) and protracted outages, unlike with overhead conductor.

For the reasons described above, installing an underground HVDC cable in Western Maine is not practicable, suitable, reasonably available to the Applicant, or less damaging to the environment.

Dated at Scarborough, Maine this 19th day of April, 2019.

By: ____________________

Gil A. Paquette

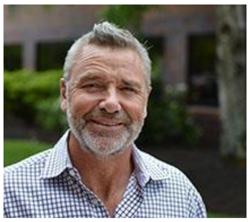
The aforenamed Gil A. Paquette did personally appear before me and made oath as to the truth of the foregoing pre-filed testimony.

Before me: ____________________

Robert B. Borowski
Attorney at Law
Bar Number: 4905

Gil Paquette, CWS, PWS

Director, Energy/Environmental Services



Education

MS, Zoology, University of Western Ontario, 1995

BS, Wildlife Management, University of Maine at Orono, 1992

Registrations/Certifications

Certified Wildlife Biologist, 2000

Professional Wetland Scientist, 2000

Gil is Director of Energy/Environmental Services and Managing Director of VHB's South Portland, ME, office. He has extensive experience providing strategic technical advisory services for large energy projects along the East Coast. He joined VHB after having been a Principal at another firm where he served as the Bangor Hydro Project Manager to develop a large multi-billion-dollar underground DC transmission line project and two large multi-million-dollar overhead AC transmission line projects.

23 years of professional experience

Emera Maine, Atlantic Link, Massachusetts to Canada

Gil served as the Permitting, Siting Lead and a member of the Stakeholder Team for the U.S. portion of the Atlantic Link Project. This proposed high-voltage direct current transmission line will deliver 1,000 megawatts of clean energy to Massachusetts from land-based wind farms and hydro facilities in Atlantic Canada through a secure, submarine transmission cable. Gil worked very closely with BOEM to permit the project. The project also required a Presidential Permit, a U.S. Army Corps of Engineers permit, and state permits.

Emera Maine/National Grid, Northeast Energy Link, Maine to Massachusetts

Gil served as Project Manager for Emera Maine leading the technical and siting team to develop a 230-mile underground HVDC transmission line from Orrington, Maine, to the Boston, Massachusetts, service area. Gil managed and conducted a routing feasibility study considering a number of routing options including overhead, submarine, and underground, prepared cost estimates for route alternative, and detailed estimates for the preferred route. Gil also led a technical study to evaluate post-operational stability and reliability of the electrical system under steady state operations.

Madison Solar Project, Madison, ME

Gil served as the Project Manager for permitting, siting, storm water management, and erosion and sedimentation control for a 5 MW solar farm in Madison, ME. At the time of completion this project was Maine's largest solar farm. All permits were secured by VHB and the project was completed on time and with no environmental issues.

Emera Maine, Eastern Maine Medical Center, Waterworks Substation, Bangor, ME

Gil served as Project Manager for siting and permitting a new substation designed to support the expanding electrical load of the Eastern Maine Medical Center. A key element of the successful siting of this important project was for VHB to create a number of visual simulations and vegetative screening to support the stakeholder process as the substation was sited in a local park. The visual simulations were key in developing consensus from various stakeholders to gain consensus on the location of the proposed facility. The project was successfully permitted and constructed.

Emera Maine, Northern Maine Reliability Solution, Maine
Gil served as Project Manager for the environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new 5-mile transmission line. He also managed the permitting process with the Department of Energy, for a Presidential Permit for Emera Maine. Gil managed a diverse assemblage of subconsultants and tasks including siting, visual analysis, archeological surveys, rare/threatened/endangered (RTE) species surveys, wetland surveys, and permitting. All permit applications were prepared, but the project was denied by the Maine Public Utilities Commission based on certain reliability criteria.

Emera Maine, MDI Transmission Upgrade, Bar Harbor, ME
Gil served as Project Manager for siting and permitting a new substation in Bar Harbor, Maine, and permitting associated transmission line upgrades in the region. All environmental permits were secured by VHB and the project was constructed.

Emera Maine, Orrington Series Capacitor, Orrington, ME
Gil served as Project Manager for the environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new Series Capacitor in Orrington, Maine. All necessary environmental permits were secured in 2015 and the Project is currently under construction.

Emera Maine, Line 85 and 87, Maine
Gil served as Project Manager for the environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for the rebuild of a 2-mile transmission line. He managed a diverse team and tasks including siting, visual analysis, archeological surveys, rare/threatened/endangered (RTE) species surveys, wetland surveys, and permitting. VHB also provided environmental monitoring services during construction. All permit applications were received and the Project was successfully completed in 2014 with zero environmental issues.

Bangor Hydro Electric Lines 51 & 93 Re-Rate Project
Gil served as Line Construction Manager for Bangor Hydro Electric leading the design, procurement process, permitting, and construction of the rebuild of a 25-mile 115 kV transmission line. Project consists of an in-kind replacement of H-frame structures coupled with an upgrade in conductor and adding fiber communications. Gil managed all aspects of the project including design, materials procurement, the contractor selection process including the RFP process, and construction.

Bangor Hydro Electric Line 64 Rebuild, Veazie to Chester, ME
Gil was Project Manager for Bangor Hydro Electric leading the design, procurement process, permitting, and construction of the rebuild of a 44-mile 115 kV transmission line. Project consisted of a total in-kind replacement of 344 H-frame structures coupled with an upgrade from single to twin-bundled conductor per phase. Gil managed all aspects of the project including design, materials procurement, the contractor selection process including the RFP process, and construction. The project was energized in December of 2011 and completed on schedule and under budget.

Bangor Hydro Electric, 115 kV Hancock County Reliability Project, ME
Gil was Project Manager for integrated engineering/ environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a 14-mile 115 kV transmission line. He managed a diverse assemblage of subconsultants

and tasks including, preliminary engineering design and siting, visual analysis, aerial photography and orthorectification of photos, archeological surveys, RTE surveys, wetland surveys, civil surveys, and permitting. The construction of the line was completed on schedule in 2008.

Bangor Hydro Electric, Northeast Reliability Interconnect, ME
Gil served as Project Manager for integrated engineering/ environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new 86-mile transmission line. He established the stakeholder process to meet with various state and federal agencies, environmental groups, and large landowners to identify issues for siting the project. He also managed the permitting process with the Department of Energy, including the NEPA process, the preparation of an EIS, and the acquisition of a Presidential Permit for BHE. Gil managed a diverse assemblage of subconsultants and tasks including, preliminary engineering design and siting, visual analysis, aerial photography and orthorectification of photos, archeological surveys, RTE surveys, wetland surveys, AC mitigation investigations, civil surveys, and permitting. Gil managed the construction of the transmission line for BHE. The transmission line was successfully completed ahead of schedule in 2007. In 2009 managed and wrote the application to amend the Presidential Permit to increase export loads.

Bangor Hydro Electric, Keene Road 345 kV Substation, Chester, ME
Gil served as Project Manager for BHE leading the siting and environmental permitting of a new 345 KV substation in Chester, ME. Gil is currently overseeing environmental compliance for construction of the project.

Maritimes and Northeast Pipeline, Inc., Maritimes & Northeast Pipeline State and Federal Permitting; Wetlands, Wildlife, and Botanical Resource Assessment
Gil served as field technician, field lead, and Project Manager for the DTA consulting team responsible for overseeing and conducting environmental baseline studies and impact assessment for several phases of the Maritimes and Northeast Pipeline. This work included coordinating DTA staff and teaming with other consulting firms to conduct extensive wetland delineation, rare plant and wildlife surveys, impact analysis, and report preparation for state and federal permitting of the project. This position also required working closely with state biologists to address a variety of permitting issues.

Gil A. Paquette

Representative Project Experience

Emera Maine, Atlantic Link, Massachusetts to Canada (2016-2018)

Gil was the Permitting and Siting Lead and a key member of the stakeholder team for the U.S. portion of the Atlantic Link Project. This proposed high-voltage direct current transmission line would have utilized a 1,000 megawatts subsea cable from land-based wind farms and hydro facilities in Atlantic Canada to Massachusetts. Gil worked very closely with BOEM, the DOE and Massachusetts permitting agencies through the Project development stage. Gil also coordinated cultural and natural resource surveys, geotechnical surveys, property and contour surveys for the converter station. The project would have required a Presidential Permit, a U.S. Army Corps of Engineers permit, and state permits.

Madison Solar Farm, Madison, ME (2015-2016)

Gil served as Project Manager for a multidisciplinary VHB team to provide permitting, survey, and civil design of a 5 MW solar farm in Madison. The project is currently Maine's largest solar facility and became operational in 2016.

Emera Maine, Eastern Maine Medical Center, Waterworks Substation, Bangor, ME (2016)

Gil serves as Project Manager for siting and permitting a new substation designed to support the expanding electrical load of the Eastern Maine Medical Center. A key element of the successful siting of this important project was for VHB to create a number of visual simulations and vegetative screening to support the stakeholder process as the substation was sited in a local park. The visual simulations were key in developing consensus from various stakeholders to gain consensus on the location of the proposed facility. The Project was successfully permitted and construed.

Emera Maine, Northern Maine Reliability Solution, Maine (2014-2015)

Gil served as Project Manager for the environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new 5-mile transmission line. He also managed the permitting process with the Department of Energy, for a Presidential Permit for Emera Maine. Gil managed a diverse assemblage of subconsultants and tasks including siting, visual analysis, archeological surveys, rare/threatened/endangered (RTE) species surveys, wetland surveys, and permitting. All permit applications were prepared, but the project was denied by the Maine Public Utilities Commission based on certain reliability criteria.

Emera Maine, Orrington Series Capacitor, Orrington, ME (2015)

Gil served as Project Manager for the environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new Series Capacitor in Orrington, Maine. All necessary environmental permits were secured in 2015 and the Project was constructed.

Bangor Hydro Electric Lines 51 & 93 Re-Rate Project (2012-2014)

Gil served as Line Construction Manager for Bangor Hydro Electric leading the design, procurement process, permitting, and construction of the rebuild of a 25-mile 115 kV transmission line. Project consists of an in-kind replacement of H-frame structures coupled with an upgrade in conductor and adding fiber communications. Gil manages all aspects of the project including design, materials procurement, the contractor selection process including the RFP process, and construction. The Project was successfully constructed.

Emera Maine/National Grid, Northeast Energy Link, Maine to Massachusetts (2007-2014)
Gil served as Project Manager for Emera Maine leading the technical and siting team to develop a 230-mile underground HVDC transmission line from Orrington, Maine, to the Boston, Massachusetts, service area. Gil managed and conducted a routing feasibility study considering a number of routing options including overhead, submarine, and underground, prepared cost estimates for route alternative, and detailed estimates for the preferred route. Gil also led a technical study to evaluate post-operational stability and reliability of the electrical system under steady state operations.

Emera Maine, Downeast Reliability Project, Ellsworth to Harrington, ME (2008-2013)
Gil has served as Permitting Manager and Construction Manager for Bangor Hydro Electric's new 43-mile, 115 kV transmission line from Ellsworth to Harrington. He managed wetland surveys, vernal pool surveys, RTE surveys, visual analysis, archeological surveys, and geotech and soil surveys as well as the preparation of all permit applications. Gil also managed construction of the project. The Project was successfully constructed.

Bangor Hydro Electric Line 64 Rebuild, Veazie to Chester, ME (2008-2012)
Gil was Project Manager for Bangor Hydro Electric leading the design, procurement process, permitting, and construction of the rebuild of a 44-mile 115 kV transmission line. Project consisted of a total in-kind replacement of 344 H-frame structures coupled with an upgrade from single to twin-bundled conductor per phase. Gil managed all aspects of the project including design, materials procurement, the contractor selection process including the RFP process, and construction. The project was energized in December of 2011 and completed on schedule and under budget.

Bangor Hydro Electric, 115 kV Hancock County Reliability Project – ME (2006 – 2008)
Mr. Paquette served as Project Manager for integrated engineering/ environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a 14-mile 115 kV transmission line. He managed a diverse assemblage of subconsultants and tasks including, preliminary engineering design and siting, visual analysis, aerial photography and orthorectification of photos, archeological surveys, RTE surveys, wetland surveys, civil surveys, and permitting. The construction of the line was completed on schedule in 2008.

Bangor Hydro Electric, Keene Road 345 kV Substation, Chester, ME (2007-2010)
Gil served as Project Manager for Bangor Hydro leading the siting and environmental permitting of a new 345 KV substation in Chester, ME.

Bangor Hydro Electric, Northeast Reliability Interconnect, ME (2004-2007)
Gil served as Project Manager for integrated engineering/ environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits for a new 86-mile transmission line. He established the stakeholder process to meet with various state and federal agencies, environmental groups, and large landowners to identify issues for siting the project. He also managed the permitting process with the Department of Energy, including the NEPA process, the preparation of an EIS, and the acquisition of a Presidential Permit for BHE. Gil managed a diverse assemblage of subconsultants and tasks including, preliminary engineering design and siting, visual analysis, aerial photography and orthorectification of photos, archeological surveys, RTE surveys, wetland surveys, AC mitigation investigations, civil surveys, and permitting. Gil managed the construction of the transmission line for BHE. The transmission line was successfully completed ahead of schedule in 2007. In 2009 managed and wrote the application to amend the Presidential Permit to increase export loads.

Central Maine Power, 69 kV Southern York County Reinforcement Project – ME (2002 – 2004)
Mr. Paquette served as Project Manager for integrated engineering/ environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits and siting and designing the line. He managed integrated engineering/permitting team including siting, developing preliminary and final design, permitting, field surveys, preparing the RFQ for construction, and environmental inspection and compliance

management during construction of a 12-mile, 69 kV transmission in Kittery, York, and Elliot Maine. Project was constructed in 2004 and is energized.

Great Lakes Hydro America, LLC and Bangor Hydro-Electric Company, 115kV Chester-Millinocket Tie Line Project – ME (2002 – 2003)

Mr. Paquette served as Project Manager for environmental project siting and permitting team responsible for obtaining necessary federal, state, and local permits. He managed environmental field studies, data collection and analysis, and assessed facility layout for proposed 25-mile, 115 kV transmission line between Millinocket and Chester, Maine. This position also required working closely with state biologists to address a variety of permitting issues. Project was permitted in record time and constructed and energized in 2003.

Patriot Project, Tennessee, Virginia, North Carolina, East Tennessee Natural Gas (2000 – 2002)

Mr. Paquette served as Project Manager for the environmental consulting team responsible for conducting environmental field investigations, preparing environmental study reports, and preparing federal and state permit applications for the proposed project. Field studies included conducting wetland delineations, conducting wildlife surveys and wildlife habitat evaluations, and searching for RTE plants and wildlife along the pipeline corridor and associated facilities. Also, solely responsible for preparing state and federal permit applications including Section 10/404 (U.S. Army Corps of Engineers) and Tennessee, Virginia, and North Carolina state permit applications. This position also required working closely with state and federal biologists to address a variety of permitting issues. The Project was successfully constructed.

Maritimes and Northeast Pipeline, Inc., Maritimes & Northeast Pipeline State and Federal Permitting; Wetlands, Wildlife, and Botanical Resource Assessment (1996-1999)

Gil served as field technician, field lead, and Project Manager responsible for overseeing and conducting environmental baseline studies and impact assessment for several phases of the Maritimes and Northeast Pipeline. This work included coordinating staff and teaming with other consulting firms to conduct extensive wetland delineation, rare plant and wildlife surveys, impact analysis, and report preparation for state and federal permitting of the project. This position also required working closely with state biologists to address a variety of permitting issues. The Project was successfully constructed.