CONNECTICUT SITING COUNCIL

IN RE:		
THE UNITED ILLUMINATING COMPANY (UI)	:	
APPLICATION FOR A CERTIFICATE OF	:	
ENVIRONMENTAL COMPATIBILITY AND PUBLIC	:	DOCKET NO. 516
NEED FOR THE FAIRFIELD TO CONGRESS	:	
RAILROAD TRANSMISSION LINE 115-KV	:	
REBUILD PROJECT THAT CONSISTS OF THE	:	
RELOCATION AND REBUILD OF ITS EXISTING	:	
115-KILOVOLT (KV) ELECTRIC TRANSMISSION	:	
LINES FROM THE RAILROAD CATENARY	:	
STRUCTURES TO NEW STEEL MONOPOLE	:	
STRUCTURES AND RELATED MODIFICATIONS	:	
ALONG APPROXIMATELY 7.3 MILES OF THE	:	
CONNECTICUT DEPARTMENT OF	:	
TRANSPORTATION'S METRO-NORTH RAILROAD	:	
CORRIDOR BETWEEN STRUCTURE B648S	:	
LOCATED EAST OF SASCO CREEK IN FAIRFIELD	:	
AND UI'S CONGRESS STREET SUBSTATION IN	:	
BRIDGEPORT, AND THE REBUILD OF TWO	:	
EXISTING 115-KV TRANSMISSION LINES ALONG	:	
0.23 MILES OF EXISTING UI RIGHT-OF-WAY TO	:	
FACILITATE INTERCONNECTION OF THE	:	
REBUILT 115-KV ELECTRIC TRANSMISSION	:	
LINES AT UI'S EXISTING ASH CREEK, RESCO,	:	
PEQUONNOCK AND CONGRESS STREET	:	
SUBSTATIONS TRAVERSING THE	:	
MUNICIPALITIES OF BRIDGEPORT AND	:	
FAIRFIELD, CONNECTICUT	:	NOVEMBER 9, 2023

PRE-FILED TESTIMONY OF REFAT AWAD, P. ENG.

Q. Please state your name, profession, and current position.

A. Refat (Ray) Awad. I am the owner of Ray Awad Inc., 103 Avenue de la Gironde, Saint Lambert, QC, Canada, J4S 1W5.

Q. What services does Ray Awad Inc. provide?

A. My company offers expert advice and manages high voltage cable projects around the world, especially underground and submarine cable projects. Through my engineering career I have worked with a variety of major international firms, along with many of the major cable suppliers in Europe and Japan. I have also audited many of the international high voltage submarine cable manufacturing facilities around the world.

Q. Please describe your educational background.

A. I received my bachelor's degree in electrical engineering from the University of Cairo in Egypt and my master's degree, also in electrical engineering, from Concordia University in Montreal, Quebec.

Q. What is your professional background?

A. I have over fifty-four years of experience in the design, manufacturing, installation, testing, maintenance and management of major High Voltage Underground and Submarine Cable Projects around the world. I previously worked for Pirelli Cables (Canada) (now known as Prysmian) from 1969 to 1979; first, as a cable engineer and later, as the Director of the Cable Engineering Department. I joined Hydro Quebec in 1979 as its Senior High Voltage Cable Engineer, where I was entrusted with the management of the company's entire High Voltage Cable Network, consisting of hundreds of circuits. Since 1979, I have added over one hundred new underground and submarine cable lines, using the new technology of Cross-Linked Polyethylene known as XLPE, at voltages up to 525 kV. I qualified the 400 kV XLPE insulated AC cables from three international manufacturers: Nexans, (Alcatel) Prysmian (Pirelli) and Fujikura, at IREQ. Nexans successfully continued the testing at 500 kV level to become the first company, worldwide, to be qualified. In 2009, I established my consulting service company, Ray Awad Inc. As noted, my company offers expert advice and manages international HV cable projects. I previously taught a specialized course on "Electrical Energy Transportation" at École Supérieure de Technologies (ETS), University of Quebec in Montreal, from 1985 to 1996. For your reference, I have appended as Exhibit A my *curriculum vitae*.

Q. Are you affiliated with any professional or industry organization?

A. My affiliations include memberships in the Quebec Order of Engineers, the Professional Engineers and Geoscientists Newfoundland and Labrador, the International Electronic and Electrical Engineers and Insulated Conductor Committee ICC, the International Council on Large Electric Systems, and the Centre for Energy Advancement through Technological Innovation.

Q. Do you hold any licenses or certifications?

A. Yes, I am a licensed Professional Engineer (P.E.).

Q. Have you published any articles or given any recent presentations on the topic of underground cable technology?

A. Yes. I have authored and published several articles and technical brochures on the installation, composition, and protection of high voltage underground cables. A complete list of my publications and recent presentations can be found in my CV attached hereto as Exhibit A.

Q. Have you performed any prior consulting work in the region?

A. Yes. I performed consulting work for the Champlain Hudson Power Express project, which is expected to link Quebec with Queens, New York by High Voltage Direct Current (HVDC). I also consulted on the Cross-Sound Cable linking New Haven, Connecticut to Shoreham, Long Island with HVDC. In 2016, I was involved in the preparation of a feasibility study pertaining to the replacement of a 115-kV fluid filled submarine cable connecting South Boston to Deer Island in Boston Harbor.

Q. Have you previously testified before the Connecticut Siting Council?

A. No, this is my first time testifying before the Connecticut Siting Council (the "Council").

Q. What is your involvement in the present proceeding?

A. I was engaged by the Town of Fairfield (the "Town"), to review the United Illuminating Company's ("UI") Application for a Certificate of Environmental Compatibility and Public Need (the "Application") and to provide facts, analysis, and opinions for the public record related to the Application and UI's request to construct and operate a high voltage overhead transmission line between Fairfield and Bridgeport (the "Proposed Project"). More specifically, I was asked by the Town to focus on UI's relocation project alternatives and cost estimates and to opine as to the feasibility, both from a cost and engineering perspective, of constructing a 115-kV transmission line underground within existing public rights of way.

Q. Have you reviewed UI's Application and all relevant documentation filed in this matter (CSC Docket 516)?

A. Yes, I reviewed all relevant documentation associated with UI's relocation project alternatives and cost estimates.

Q. Have you reviewed UI's estimated cost for constructing underground transmission lines?

A. Yes, I have. Among other documents, I reviewed UI's response to Interrogatory CSC-14, attachment CSC-14-1 and UI's late filed Exhibits 2-5-1.

Q. In your professional opinion, is UI's cost estimate for constructing underground transmission lines reliable and consistent with industry standards and expectations?

A. No. UI estimates the total cost of constructing and installing approximately 9.14 miles of underground transmission cable at $1,000,585,500. This can be broken down to a cost per mile of over $100,000,000. In my professional opinion, both UI's total cost estimate and its transmission line cost estimate ($976,504,000) are outrageously inflated and should not be accepted by the Council as reliable.

Q. Are you familiar with the Council's Life-Cycle Cost Analysis Report dated January 5, 2023?

A. Yes, I am.

Q. Are UI's cost estimates for the construction and installation of underground transmission cables consistent with the findings of the Council's Life-Cycle Cost Analysis Report?

A. No, they are not. Based upon information supplied to the Siting Council by Eversource, Connecticut's other transmission owner, the Council concluded that the first cost (i.e., the cost to design, permit and build a line) associated with 115-kV XLPE underground cable is $20,840,500 per mile and the total-net-present value cost associated with 115 kV XLPE underground cable is $28,389,467 per mile.

Q. Did you prepare a report for this matter entitled "Report to respond to the initialization cost estimates submitted by United Illuminating, CT for the Fairfield to Congress Railroad Transmission line 115 kV rebuild project in the town of Fairfield and the city of Bridgeport, CT"?

A. Yes, and a copy of that report is attached hereto as Exhibit B.

Q. As part of your report, did you prepare a cost estimate for undergrounding UI's proposed project?

A. Yes, I did.

Q. What work did you perform to prepare your Report?

A. Besides reviewing UI's Application materials and the Council's Docket, I physically inspected the route proposed by UI in Figure 9-1 of its Application and met and consulted with the Fairfield Town Engineer, William Hurley. I contacted two firms, Prysmian USA, the largest high voltage cable manufacturer in the world, and Elecnor Hawkeye LLC, a construction contractor with experience undergrounding high voltage transmission lines in the northeastern United States, to obtain material and civil engineering cost estimates for the underground installation of approximately 7.4 miles of 115-kV transmission line and evaluated the schedule estimates provided by UI. Based on my site inspection and correspondence with reputable local contractors, I was able to develop an estimate of the total cost and timeline associated with installing high voltage cross-linked polyethylene (XLPE) cables underground within the route proposed by UI in Figure 9-1 of its Application.

Q. Will you please summarize your findings regarding the cost of an underground cable route?

A. Based upon the material and civil engineering cost estimates provided, I concluded that the cost of a 115-kV underground single-circuit XLPE cable line along the route proposed by UI is $172,400,000 or approximately $23.3 million per mile (See Table 1 in my Report). The cost of a double-circuit XLPE cable line along the same route is $200,700,000 or approximately $27.1 million per mile (See Table 2 in my Report). These estimates contrast sharply with the budgetary estimate provided by UI, which, in my professional opinion, is inflated by a factor of around five (5).

Q. UI has asserted that existing underground utilities are likely to drive up the cost of underground work. In your view, could such existing utilities account for UI's budgetary estimate?

A. No. My study of the route and my consultation with Fairfield's Town Engineer and staff within the Engineering Department, suggest that any costs associated with this route would be typical. Furthermore, I have consulted on many underground cable projects that run through dense urban areas, where hundreds of years of pipes, cables, and other utilities have been built underground. None had a per-mile cost figure that was even remotely similar to the figure that was provided by UI.

Q. How did you assess UI's claims about the expected timeline for this underground work?

A. I drew on my experience with dozens of similar projects, and on schedule estimates from the contractors who contributed to my budgetary estimate.

Q. What were your conclusions?

A. I found that the duration of this project in UI's filings was inflated by a factor of three (3) or more. The five (5) day work week assumed by UI ignores the industry norm of using multiple crews in rotation. Further, the engineering and procurement stage could likely be completed in 14 months, while the construction of duct banks and installation of cable, per Elecnor Hawkeye's estimate, could be completed in 22 months. Overall, the project could be completed in about 3 years. In my view, there is no reasonable basis for estimating that the underground work would take 10 years.

Q. Are there benefits associated with installing transmission lines underground?

A. Yes, there are numerous health and safety benefits associated with undergrounding transmission lines.

Q. Briefly, what are some of the benefits?

A. The principal advantages of underground transmission lines are:

- Social acceptability. Based on our experience, almost all the proposed underground cable transmission lines projects are accepted by the surrounding communities.

- Efficient use of land. Less acreage is required for the easement and/or right of way, and cable ducts are built mostly under public roads.
- Higher Reliability. Underground lines have a lower rate of faults, enhanced by installing DTS and DAS monitoring of temperature and acoustic noise using Optic Fiber cables.
- Not impacted by major environmental events. These events include lightning, wind, ice storms , and brush fires.
- Lower annual operating and maintenance cost.
- Lower environmental impact. Underground lines involve a major reduction in the need to clear mature trees.
- Public safety. The risk of falling conductors or vehicle accidents with poles is eliminated.
- No electric field. There is effectively no electric field outside the cables.
- Low magnetic fields. Magnetic fields attenuate rapidly with distance from the buried cables.
- No visual impact.
- No impact on surrounding property value.

Q. What are your overall conclusions with respect to UI's application?

A. As detailed in my report, the underground route which UI proposed in its application is not only feasible but could be completed under a reasonable timeline and budget. My report also details some of the benefits of an underground route and of underground cable technology. Since I am unable to replicate UI's budgetary or scheduling estimates, I believe the benefits of this underground option should be seriously considered.

Q. Does this conclude your testimony?

A. Yes. However, I reserve the right to submit supplemental pre-filed testimony and exhibits, as needed, in response to any new information or late-filed exhibits submitted in this proceeding.

EXHIBIT A

4RAY (REFAT) AWAD, P. ENG.

High Voltage Cable Expert

PROFILE

Mr. Awad has over forty-three years of experience in the design, manufacturing, installation, testing, maintenance and management of major High Voltage Underground and Submarine Cable Projects around the world. Mr. Awad worked for Pirelli Cables (Canada) (now known as Prysmian) from 1969 to 1979; first, as a cable engineer and later, as the Director of the Cable Engineering Department.
He joined Hydro Quebec in 1979 as Senior High Voltage Cable Engineer, where he was entrusted with the management of the entire High Voltage Cable Network comprising of some hundred circuits: mainly Fluid Filled Cables. He since has added over one hundred new underground and submarine cable lines, using the new technology of Cross-Linked Polyethylene known as XLPE **up to 525 kV** as well as some Submarine cables.
He qualified the 400 kV XLPE insulated AC cables from three international manufacturers: Nexans, (Alcatel) Prysmian (Pirelli) and Fujikura, at IREQ. **Nexans** successfully continued the testing at 500 kV level to become the first company, worldwide, to be qualified.
Mr. Awad established his consulting service company (Ray Awad Inc.). in 2009 to offer expert advice and manage HV cable projects around the world. He has taught a specialised course on the “Electrical Energy Transportation” at École Supérieure de Technologies (ETS), University of Quebec in Montreal, from 1985 to 1996.
Mr. Awad was involved in many Underground and Submarine Cable projects in Canada and around the world. He has worked with major international consultants, Utilities and Law Firms. He is remarkably familiar with the Cable industry and has dealt with almost all the major suppliers in Europe and Japan. He audited most of the international High Voltage Submarine cable manufacturing facilities around the world.

EDUCATION

Master’s degree in electrical engineering, Concordia University, Montreal, Quebec, Canada	1973
Bachelor’s degree in science, Electrical Engineering, Cairo University, Egypt	1966

AWARDS

Award for the best technical paper on “The Evaluation of the State and Performance of Oil Filled High Voltage Cables”, Jicable’07.	2007
Technical award for best Technical Brochure (no. 283) on “The protection of High Voltage Cable Sheaths”, CIGRE	2006
Award for best educational presentation, Dallas Texas, USA, IEEE, ICC (Insulated Conductor Committee)	2003

PROFESSIONAL ASSOCIATIONS

Ordre des ingénieurs du Québec (#24288)	OIQ
Professional Engineers and Geoscientists Newfoundland and Labrador (#07039)	PEGNL
International Electronic and Electrical Engineers and Insulated Conductor Committee ICC (Life member)	IEEE/ICC

International Council on Large Electric System (Study Committee B1; Insulated Cables) Jicable organisation; Versailles, France; Sinc 1995	CIGRE
Centre for Energy Advancement through Technological Innovation (Canadian and American group of High Voltage cable specialists)	CEATI

CAREER

Mr. Awad's career included the design, manufacturing, installation, testing and project management of major HV underground and submarine cables in Canada and around the world. He has demonstrated leadership and team building as well as mentoring young engineers. Consultant, High Voltage Cable Expert, Energy, CIMA+, AECOM, SNC-Lavalin, Hatch, and others	2012 – Present
President, High Voltage Cable Expert, Ray Awad Inc., Montreal, Quebec, Canada President of the technical and scientific committee, Jicable2011, Versailles, France	2009 – Present
Senior High Voltage Cable Engineer, Hydro-Québec, Montreal, Quebec, Canada	1979 – 2009
Lecturer of the Electrical Energy Transportation course, Ecole Supérieure de Technologies; ETS; University of Quebec in Montreal, Québec, Canada	1985 – 1996
Cable Engineer, Director of the Cable Engineering Department, Pirelli Cables (Canada) (now known as Prysmian), Montreal, Quebec, Canada	1969 – 1979

PROFESSIONAL EXPERIENCE

High Voltage Underground and Submarine Cable Studies and Projects

- SNC Lavalin; support engineer for two 320 kV and 400 kV DC **submarine cables** in Abu Dhabi. Projects are currently in the supply phase by Prysmian and Sumitomo.
- WSP (USA); HV Cable expert for the **CHPE 400 kV DC** XLPE insulated cables between Hertel CS and NYC, the installation will commence in 2024; Ongoing,
- WSP Canada; feasibility study of **two 400 kV DC submarine cables** crossing the St Lawrence River; part of the interconnection between Quebec and New Brunswick, Canada.
- CIMA (Ontario), Undergrounding one span of 230 kV Overhead Transmission Line at St. Clair SS, St. Clair, On.
- Manager; EPC procurement package; **Soo Green** Direct Link; High Voltage **525 kV DC**, 560 km underground Cable between Iowa and Illinois, USA (2020-on going).
- Feasibility study for crossing the Western Great Slave Lake using **230 kV submarine cables**, for the Government of the Northwestern Territories', Canada.

- Undergrounding five **115 kV and 230 kV** OHTL for Hydro One in Windsor (2016-2019)
- WSP Canada; Two 225 kV XLPE insulated **Submarine cables** to be installed in the bay of Gore, Senegal 2018.
- AECOM Canada, a study of 320 kV DC **submarine cable interconnection** between Ontario and Pennsylvania in Lake Erie. Project is now in the process of bidding.
- WSP Canada; design and cost estimates of the entire 225 kV underground and submarine cable network of the city of Dakar, Senegal. The project is currently in the implementation phase under the USA 540 million Dollar **M**illenium **C**hallenge **C**orporation (**MCC**), Senegal Compact.
- Replacement of **245 kV** oil filled cables by XLPE insulated cables at the Churchill Falls power generating station, Nalcor, Labrador, Canada (2009-present), This is an on-going project at the rate of one circuit per year.
- Feasibility study for the replacement of the **115 kV Fluid Filled submarine cable** between South Boston and Deer Island (Boston Harbor), AECOM Canada, 2016.
- Design, procurement, and installation of two three conductor **25 kV submarine cables** between St. Johns and Bell Island, Newfoundland (2015).
- Bidding, with AECOM USA on the Chino Hills **500 kV** AC, XLPE insulated cable project (2014).
- Owner's Engineer; AECOM NYC, USA, **Champlain Hudson Power Express** (CHPE), 550 km 400 kV DC **underground and submarine cable** interconnection between Hydro Quebec (Canada) and the NY; USA; 2013-2014.
- Study of a 900 km, **500 kV**, **DC Submarine cable**, Chile (2010-2011)
- Study of a **150 kV DC submarine cable** connection between Hydro Quebec network and the Magdalene Islands in the Gulf of St. Lawrence (2010-2011). Project is now in the tendering stage.
- Feasibility study of the **320 kV** DC XLPE insulated **submarine cables** interconnection between Ontario (Hydro One) and Pennsylvania in Lake Erie (AECOM, Canada)
- Engineering of two **500 kV DC** MIND **submarine cable** interconnections between Egypt and the Kingdom of Saudi Arabia across the Gulf of Aqaba (2009-2010). Project is currently in the installation phase.
- Study of two 500 kV AC underground cable circuits for the Heartland project, Alta link, Alberta, Canada (2008-2011)
- Recommendations for testing **500kV AC XLPE insulated** cables in Porce III, Bogota, Columbia (2010).
- Design and Installation of two, 40 km, **400 kV AC** Fluid-Filled submarine cables between the Kingdom of Saudi Arabia and Bahrain including a pumping plant (GCCIA, 2007-2010)
- Replacement of 230 kV oil filled cables by XLPE insulated cables at La Fortuna power generating station, David City, Panama (2004)
- Installation of a **150 kV DC** submarine cables between Massachusetts and Long Island New York (USA), known as the Cross-Sound Cable; this project was carried out in partnership between HQI (Hydro Quebec International) and ABB, Sweden (2001-2002).
- Installation of three underground cable circuits operated at **88 kV DC** in Australia. This Direct-Link project was carried out in partnership between HQI (Hydro Quebec International) and ABB, Sweden. This project is known as Direct Link (1998-2000)
- Installation of an underground cable circuit operated at **150 kV DC** in Australia. This Murray Link project was carried out in partnership between HQI (Hydro Quebec International) and ABB, Sweden (2000-2002)
- Auditing of AC and DC High Voltage **underground and submarine cable manufacturing facilities** around the world; ABB (now NKT) Karlskrona Sweden, Hellenic cables (Greece), LS Cable and System (Korea), Nexans (Halden, Norway), Prysmian (Naples, Italy, 2010) and Viscas (Fujikura and Furukawa, (Tokyo, Japan).

- Installation of **two 400 kV oil-filled submarine cable** circuits between the Kingdoms of Saudi Arabia and Bahrain (GCCIA), 2009-2010.
- Qualifying the XLPE insulated cables from three major cable manufactures for the 400-kV class (1995-1997). Nexans was the first to be qualified for 500 kV at IREQ: Hydro Quebec research laboratories.
- A list of other projects and studies carried out with major consultants would be submitted upon request.

PUBLICATIONS AND PRESENTATIONS

Publications

- CIGRE Technical Brochure No.194 on "Installation and Laying techniques of High Voltage Cables around the world", 2000.
- CIGRE Technical Brochure No.403 on "Installation of High Voltage Cables in multi-purpose and shared structures", 2006.
- CIGRE Technical Brochure No.283 on "Protection of High Voltage Cable Sheaths" 2006. **Best technical award for 2006.**
- Jicable; "The evaluation of the state and performance of High Voltage Fluid-Filled Cables at Hydro Quebec". **Best technical paper award of the conference, 2007**.
- New generation of High Voltage Cables at Hydro Quebec (Jicable 2003).

Presentations

- President of the Technical and scientific committee, Jicable 2011, Versailles, France.
- Canadian representative on the CIGRE Working Group 21-19 which prepared the Technical Brochure No. 283 covering the technical aspects of the different installation techniques of HV Cables around the world (2002-2006)
- Convenor of the CIGRE Working Group B1-08 responsible for the Technical Brochure No. 403 on "Cables systems in multipurpose or shared structures", 20082010.
- CEATI Vancouver, Underground HV cable workshops 2001 and 2008.
- IEEE T&D Los Angeles, CA Conference Proceedings (#96CH35968), Successful Testing of 345 kV XLPE Cables and Pre-moulded Joint at IREQ (1996).

EXHIBIT B

Report to respond to the initialization cost estimates submitted by United Illuminating, CT

for the Fairfield to Congress Railroad Transmission line 115 kV rebuild project

in the Town of Fairfield and the City of Bridgeport, CT

Prepared by

Ray Awad, High Voltage Cable Engineer

President and Principal Engineer

Ray Awad Inc.

103 Avenue de la Gironde

Saint Lambert, QC

Canada, J4S 1W5

1. INTRODUCTION

Electrical utilities around the world must choose between High Voltage Overhead Transmission Lines (OHTL) and Underground Cables (UGC) for the transportation of energy between generating stations and different substations in their network.

It is observed that utilities usually prefer the OHTL solution without considering UGC. This is mainly because of their engineers' unfamiliarity with UGC and the inherent higher cost of insulated cables, accessories, construction, and installation associated with UGC.

However, UGC offers many advantages, as described below – particularly their higher reliability, lower operating and maintenance costs, lower environmental impact, and more efficient use of land.

Moreover, UGC does not have any outside electric field, as they are shielded. They also have lower magnetic fields which decay (attenuate) very rapidly, in short distance from the cables, thus reducing health risks to the surrounding population. Underground cable lines are readily "socially acceptable" as they are built mainly under city streets and do not require large easements or the cutting of mature trees**.**

I have physically inspected UI's proposed route for the 115 kV south circuit underground alternative between the Structure no. P648S and the new Pequonnock substation, as well as the existing Congress substation.

It is my professional opinion that it is feasible, from both a cost perspective and an engineering perspective, to underground the south circuit along the proposed route.

This report also includes a realistic budgetary estimate (variation -10%, +25%) and a schedule for the proposed project between the connection point between UI and Eversource in Fairfield at structure no. P648S, possibly looping at Ash Creek substation, and terminating at the new Pequonnock Station.

It is observed that the double circuit connection between Congress substation and the new Pequonnock substation is underway.

The material costs for our estimate have been provided by Prysmian, the world leader in High Voltage Cable manufacturing. The civil construction and cable system installation estimates are provided by Hawkeye, a major underground contractor operating in the Northeastern United States.

The cost of the final acceptance testing, which will be carried out by an independent qualified service provider in accordance with national standards, is also reported.

It is highly recommended to consider the construction of civil works for the possible undergrounding of the north circuit in the future.

1. Advantages of Underground Cable Transmission Lines

Underground cable transmission offers many major advantages. The main advantages are listed below:

- **Social acceptability.** Based on our experience, almost all the proposed underground cable transmission lines projects are accepted by the surrounding communities.
- **Efficient use of land.** Less acreage is required for the easement and/or right of way, and cable ducts are built mostly under public roads.

- **Higher Reliability.** Underground lines have a lower rate of faults, enhanced by installing DTS and DAS monitoring of temperature and acoustic noise using Optic Fiber cables.
- **Not impacted by major environmental events.** These events include lightning, wind, ice storms, and brush fires.
- **Lower annual operating and maintenance cost.**
- **Lower environmental impact.** Underground lines involve a major reduction in the need to clear mature trees.
- **Public safety**. The risk of falling conductors or vehicle accidents with poles is eliminated.
- **No electric field.** There is effectively no electric field outside the cables.
- **Low magnetic fields.** Magnetic fields attenuate rapidly with distance from the buried cables.
- **No visual impact**.
- **No impact on surrounding property value**.

It should be noted that costs related to the acquisition of easement and/or the Right of Way (ROW) for the project are beyond the scope of this report.

2. Proposed 115 kV Undergrounding of OHTL Transmission Lines between Structure P648S and Pequonnock Substation

The cables considered for these circuits are 115 kV Cross-Linked-Polyethylene (XLPE) Insulated, with a 4,000 KCM oxidized copper conductor. The cables are insulated in a vertical tower ensuring the highest concentricity of the conductors. Dry curing and dry cooling are also used to eliminate the possible ingress of humidity in the insulation. This is state-of-the-art in cable manufacturing. The oxidized conductor has a lower electrical resistance than regular ones, thus reducing the cost of losses over the lifetime of the line.

These cables will be installed in PVC ducts and a joint vaults system, which allows for the separation of civil construction work from cable pulling, jointing, and termination.

A Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) System could be added, at a reasonable additional cost, to continuously monitor the cable temperature, and detect any mechanical activities along the entire cable route.

Figure 1. Typical 115 kV Underground High Voltage XLPE insulated cable (courtesy of Nexans)

See also details of the Prysmian XLPE insulated cable with 115 kV 4,000 KCM segmented and oxidized copper conductor, overall diameter 4.36".

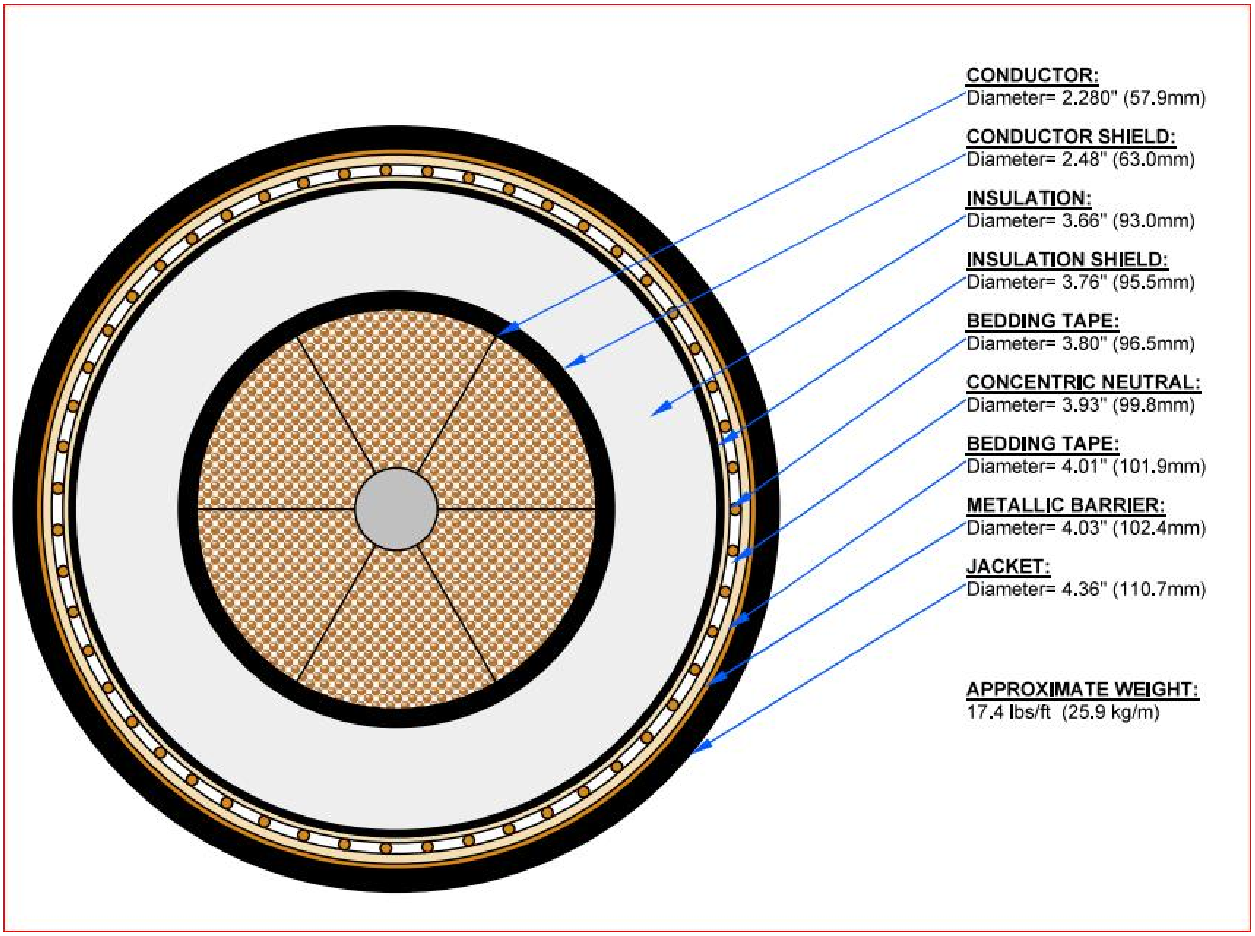

Figure 2. Proposed insulated 115 kV XLPE Cable cross section

As described above, High Voltage Cables are insulated using polymeric materials such as Cross-Linked Polyethylene (XLPE). The cables are operated at a maximum conductor temperature of 90 ºC under normal conditions. Based on accelerated aging tests carried out on this insulation, manufacturers and international standards guarantee a minimum lifespan of 40 years. However, the XLPE insulated cables manufactured today provide long and reliable service for more than 60 years.

3. Cable route

On October 24 and 25, 2023, I visited and examined the proposed 115 kV transmission cable route which UI proposed. The route runs for approximately 7.4 miles, as shown in Figures 3 and 4 below.

I also met with the Fairfield Town Engineer, Mr. William Hurely, to obtain information about the subsoil on the existing 345 kV underground route (between Middletown and Norwalk), as well as that of the new 115 kV cable circuit route, shown in Figures 3 and 4 below.

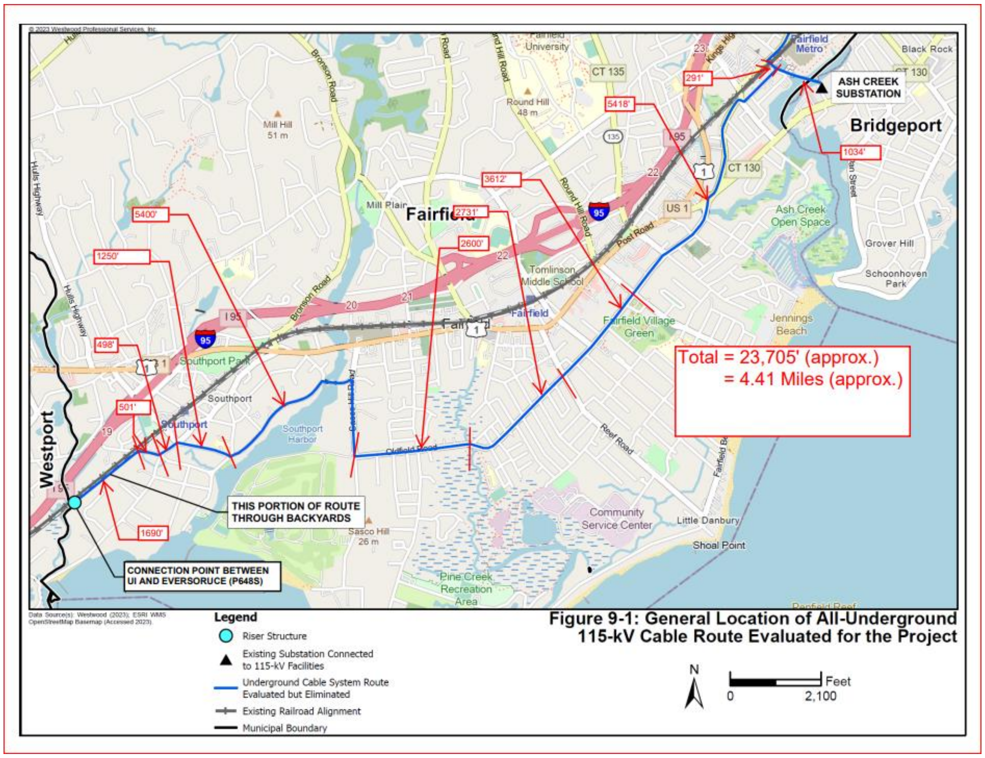

Figure 3. UI proposed 115 kV underground cable route between Structure no. P648S and Ash Creek substation

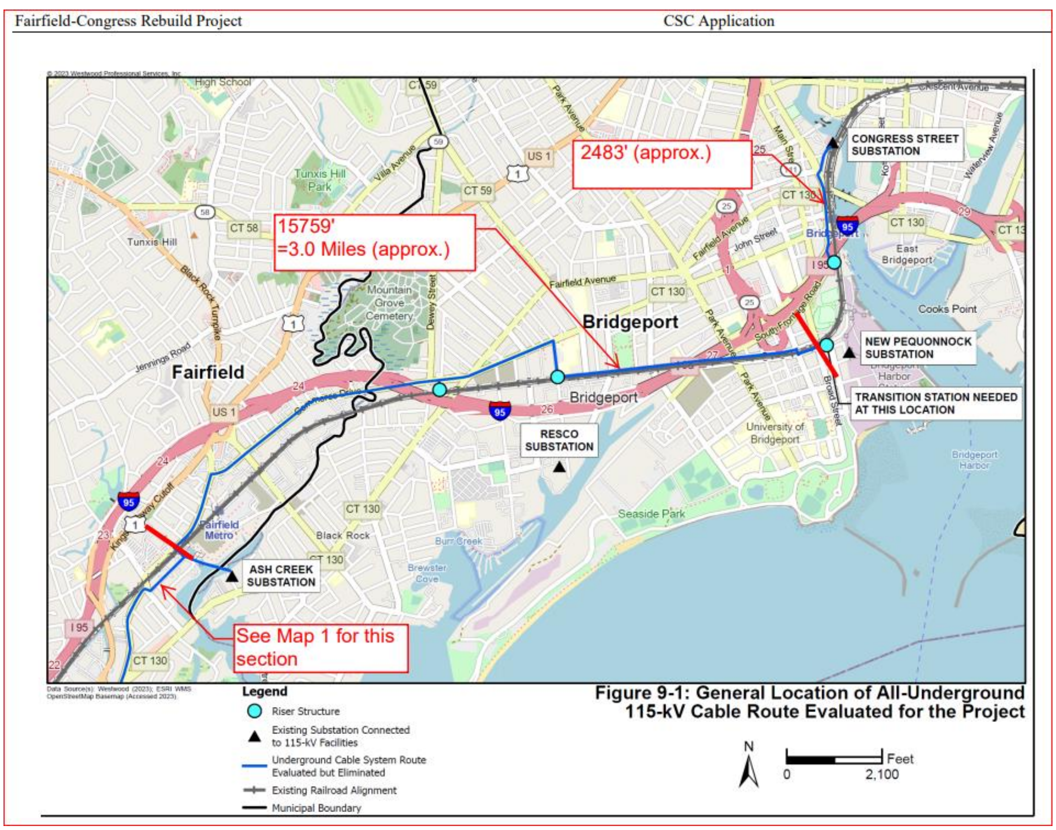

Figure 4. UI proposed 115 kV underground cable route between Ash Creek substation and Pequonnock substation

The new, single-circuit 115 kV underground cables would be installed in 2 x 2, concrete-encased, 6” ducts. The double-circuit cables would be installed in a 4 x 2, concrete-encased, 6” duct bank. Two 2” PVC ducts would be added to accommodate the Ground Continuity Conductor (GCC) and the optic fiber cable.

The cable joint would be housed in precast concrete manholes (or joint bays), shown in Figure 5 below, which reduces the time for constructing the line.

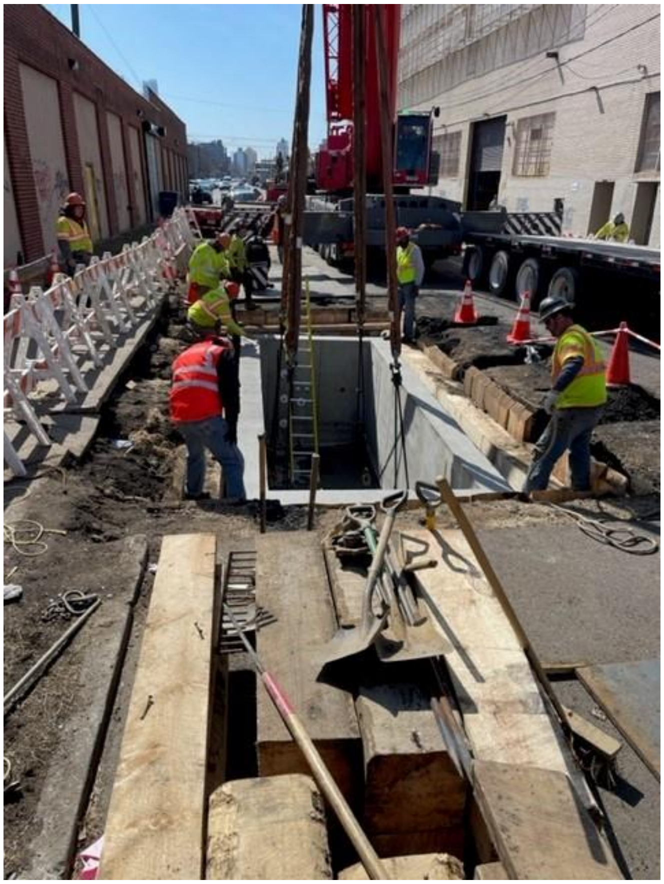

Figure 5. Placing a precast concrete manhole.

Considering the remote location of Structure no. P648P, the cable terminations and their protective lightning arresters could be attached directly to the monopole, thus reducing the footprint of the transition between the OHTL and the underground cables at that location as shown on Figure 5, below. A similar arrangement could be used for double circuits, as shown in Figure 7, below.

Figure 7. Transition of one circuit from OHTL to underground cables (Ref. CIGRE TB-250)

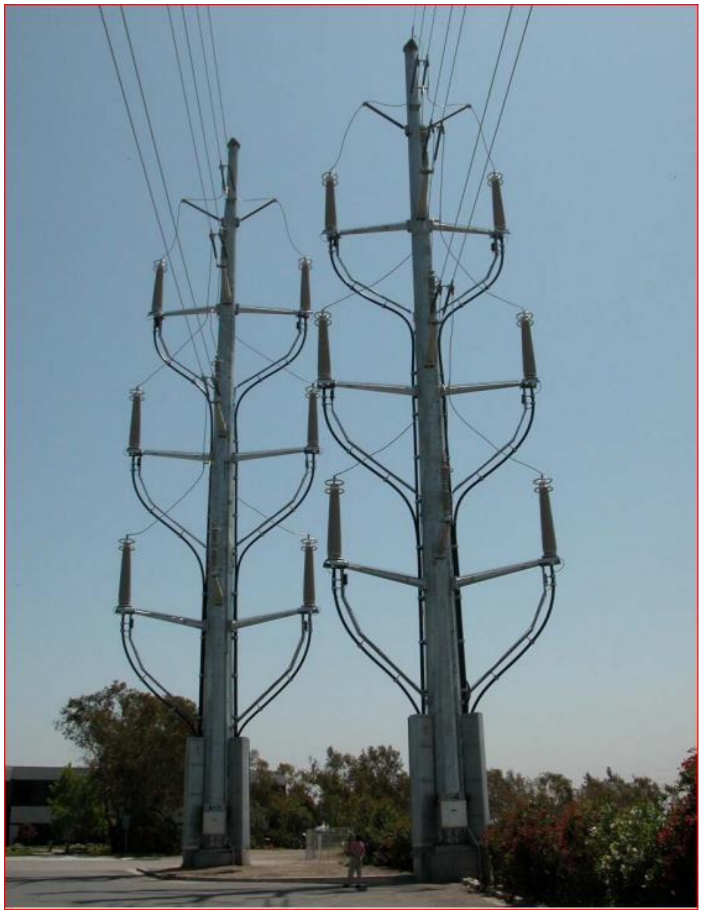

Figure 8. Transition of two underground cable circuits to OHTL on a single monopole.

Note that cables are protected at the lower part. (Ref. CIGRE TB-25)

It is worth mentioning that the proposed underground cable route could be further optimized, during the engineering phase, to reduce the cost and construction duration of the project.

We opted to evaluate the cost based on the UI's preferred route. However, the feasibility of collocating the 115 kV cable circuit along the same route of the 345 kV should not be discarded and could be examined later.

4. Budgetary Cost Estimate and Preliminary Schedule

4.1 Budgetary Estimates

Budgetary cost estimates of cables and accessories were obtained from Prysmian USA, the largest HV cable manufacturer in the world.

The civil construction and the electrical installation cost estimates were obtained from Hawkeye of NJ, an experienced construction company.

The figures in the next paragraph are budgetary estimates for the construction of one and alternatively two 115 kV underground cable circuits (lines) 7.4 miles in length between Structure no. P648S, Ash Creek and the new Pequonnock Substations (as shown in Figures 7 and 8 below).

Budgetary estimate of a single 7.4 mile, 115 kV Underground cable circuit

Item	Million $$
Supply of cables and accessories	18.6
Hardware for the support of cables and joints	0.80
Construction of duct banks and joint vaults (civil) and installation of cables and accessories (electrical) *	101.3
Design Build (Option) Engineering	16.0
Final acceptance tests	1.0
Finance and administration 20%	27.5
Contingecy 5%	7.2
Total	**172.4**

Average cost per mile	**23.3**

* Labor cost is adjusted for 2026-2027

Table 1. Cost estimate of one 115 kV underground cable circuit

Budgetary estimate of a double 7.4 miles, 115 kV underground cable circuits

Item	Million $$
Supply of cables and accessories	37.1
Hardware for cables and joints support	1.6
Construction of duct banks and joint vaults (civil) and Installation of cables and accessories (electrical) *	101.3
Engineering Design Build (Option)	19.0
Final acceptance tests	1.5
Finance and administration 20%	**32.2**
Contingecy 5%	8.0
Total	**200.7**

Average cost per mile	**27.1**

* Labor cost is adjusted for 2026-2027

Table 2. Cost estimate of two 115 kV underground cable circuits

As shown above, it is estimated that the cost of one 115 kV underground cable circuit of 7.4 miles would be $**172.4 million** and that of two circuits would be $**200.7 million**. This is approximately $23.7 million per mile for one 115 kV underground cable circuit and $27.1 million for a double circuit in the same duct bank and with staggered manholes.

Undergrounding the North circuit in the future should be considered in the strategic planning of UI High Voltage Transmission network.

Notes:

1. The cost of cables and accessories will be adjusted at the time of order.
2. The cost estimate does not include environmental studies and the cost of easements (if required).
3. The budgetary estimate does not include the accrued cost of O&M and energy loss in the cables over the lifetime of the line.
4. **Schedule** - It is estimated that the project could be completed in **three years**. This includes 14 months for engineering activities, the preparation of the necessary special studies, and material procurement. The construction and installation of the cable system could be achieved in 22 months as per the attached schedule prepared by Hawkeye.

5. **References -** The construction and installation contractors have provided a reference for a recent High Voltage Cable project; please see attached files.

6. **Refuting the Submitted UI "Initializations estimate" of the Project -** The "initialization cost estimates" submitted by UI (Volume 1, March 2023) are totally unrealistic and contradict the established project estimating methods.
   - A. The analysis of the proposed UI route for undergrounding the South circuit submitted by UI is "feasible."
   - B. The "initialization estimate" is unrealistic both in cost and schedule, and thus it is "unacceptable." It includes too many items that are unrelated to the actual underground cable circuit under consideration. Moreover, it assumes without proper support that the trenching rate of the civil contractor will be only 40 feet per day and concludes that the project will not be completed before the year 2034**.** It completely ignores the fact that construction contractors deploy multiple crews along the underground cable route to meet the required completion date.
   - C. The cost of financing the project during the very long period above exceeds the real cost of undergrounding the recommended double cable circuits.
   - D. The precision of the estimate is very poor (-50% + 200%). This may indicate that UI would not be able to initialize the project in the first place.

7. Conclusion and Recommendations

7.1 Conclusions

Following the technical analysis and the information collected during the physical site visit of the UI recommended route for undergrounding of the south circuit, it is concluded that:

a. The undergrounding of the South 115 kV line is feasible**.**
b. The budgetary cost estimate per mile of 115 kV underground cable of single circuit is **23.3 million dollars per mile** and that for a double circuit, in the same duct bank and staggered manholes) it is **27.1 million dollars per mile**.

7.2 Recommendations

It is recommended that:

a. The undergrounding of the south circuit between Structure P648S and the new Pequonnock substation be considered.
b. Duct banks and joint vaults be built for undergrounding the North circuit in the future when it would be included in UI's strategic planning.