NOVA SCOTIA POWER INC.

TRANSMISSION & DISTRIBUTION ENGINEERING DEPARTMENT

FACILITIES STUDY INFRA-STRUCTURE REPORT FOR IR#598

Addition of 2.52MW of Tidal Generation at 90N-FORCE Substation

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Facilities Study Report

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Project: Addition of 2.52MW Tidal Generation at 90N–FORCE Substation

Date: 2022-02-04 Rev. No.: 1

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1.0 INTRODUCTION:

In accordance with Section 8.3 of the Standard Generator Interconnection Procedures, the Transmission Provider is required to utilize existing studies to the extent practicable in performing new Facilities Studies. As such, Sections 2 – 8 of this report make extensive use of the Facilities Studies that were performed for IR#516 and IR#517.

IR#516 and IR#517 were two tidal Interconnection Requests studied simultaneously in 2015 that utilized the 90N-FORCE substation to connect to the NSPI transmission system. These IR's subsequently provided the funds to install the required NSPI System Network Upgrades (NU), and the Transmission Providers Interconnection Facilities (TPIF) between the NSPI transmission system and 90N-FORCE. Since that time, IR#517 has been withdrawn, and another IR has been submitted in its place (IR#542).

While no additional NSPI infrastructure will be required for IR#598 beyond what was installed for IR#516 and IR#517, a capital contribution towards the cost of the shared TPIF will be required from IR#598 in the amount of $350,658 plus $53,033 (HST), for a total of $406,590. This amount includes a 1/4 share of the original TPIF costs plus a 1/3 share of the remaining site commissioning costs that are estimated at 10,000 including HST ($2,899 plus HST each).

Sections 2-8 of this report are essentially a re-statement of the Facilities Study that was completed for tidal projects IR#516 and IR#517 in 2015. They document the requirements that were necessary to provide for the establishment of the 69 kV system interconnection at 37N-Parrsboro to supply the FORCE Substation (90N) located on the West Bay Rd. just outside the Town of Parrsboro (approx. 10km from NSPI's 37N-Parrsboro Substation. The final costs associated with the work to complete the NU and the TPIF for IR#516 and IR#517 are included to demonstrate the appropriate capital contribution requirement for IR#598.

System	Description
	The original Facilities Study for IR#516 and IR#517 was performed by R.L. Johnson, P.Eng, in June of 2015.
1.1	**Interconnection Request (IR)#598**
	This Interconnection Facilities Report is based on the Revised Standard Generator Interconnection Procedures as approved by the UARB on June 10, 2016. The interconnection service is designated Energy Resource Interconnection Service (ERIS).
	IR#598 is a 2.52MW Interconnection Request for tidal generation to be installed at the Fundy Ocean Research Centre for Energy (FORCE). The facility consists of 6 platforms of 6 tidal generators each producing 70kW at 460V for a total of 6 x 6 x 70kW = 2.52 MW. Generation is subsequently stepped up to 13.8kV and connected to the 90N-FORCE substation via a subsea cable. Connection to the NSPI transmission system is accomplished via the 90N-FORCE 13.8kV-69kV substation, a facility owned and operated by FORCE but controlled by NSPI under a Facilities Control Agreement effective as of October 1, 2020.
	The defined Point of Interconnection (POI) for IR#598 is the existing 69kV bus at Nova Scotia Power's 37N-Parrsboro Substation. The Point of Change in Ownership between NSPI and FORCE is at the line terminal structure at 90N.
	The existing transmission line between the 37N-Parrsboro Substation and the 90N-FORCE Substation (L-5582) has been built to 138kV standards but is currently operating at 69kV.
	The one line diagram, as provided by the Interconnection Customer (IC), for the interconnection to Nova Scotia Power's transmission system is shown in Appendix A.

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1.2	**IR#516, IR#517, and IR#542**

At present, there are two IR's ahead of IR#598 in the Queue that also utilize the 90N-FORCE substation: IR#516 & IR#542. IR#516 was processed in 2015 with another IR that has subsequently been withdrawn (IR#517), and these two projects were responsible for establishing the 69kV supply to FORCE.

The 69kV facilities required for IR#516 and IR#517 were built in 2016 and 2017 and construction funds were provided in advance by these interconnection Customers based on good faith best estimates and the scope of work defined in each of their Facility Study Reports. The associated construction work has since been completed and the project has been final costed. Approximately $10,000 of commissioning work remains to be completed after generation is installed.

In accordance with Section 9.9.2 of the Standard Generator Interconnection and Operating Agreement (GIP Appendix 6), IR#598 will be responsible to provide a capital contribution for the shared portion of the TPIF associated with this work. Section 9.9.2 refers to third party usage and states:

> If required by Applicable Laws and Regulations or if the Parties mutually agree, such agreement not to be unreasonably withheld, to allow one or more third parties to use the Transmission Provider's Interconnection Facilities, or any part thereof, Interconnection Customer will be entitled to compensation for the capital expenses it incurred in connection with the Interconnection Facilities based upon the pro rata use of the Interconnection Facilities by Transmission Provider, all third party users, and Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually-agreed upon methodology. In addition, cost responsibility for ongoing costs, including operation and maintenance costs associated with the Interconnection Facilities, will be allocated between Interconnection Customer and any third party users based upon the pro rata use of the Interconnection Facilities by Transmission

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Provider, all third party users, and Interconnection Customer, in accordance with Applicable Laws and Regulations or upon some other mutually agreed upon methodology. If the issue of such compensation or allocation cannot be resolved through such negotiations, it shall be submitted to the Board for resolution.

As IR#598 is the fourth project to share the TPIF, it must provide a capital contribution equal to 1/4 of the total TPIF costs, to NSPI. This payment will be refunded to the previous IR's to partially offset their contributions to the total TPIF cost. In addition, IR#598 will be responsible for its share (1/3) of all ongoing maintenance and operations costs associated with the TPIF. Should the number of third-party users change, the cost responsibility will also change in proportion to the number of third-party users. In the event additional projects are added at FORCE, IR#598 will receive a refund to partially offset their portion of shared TPIF costs.

Note that Sections 2-8 of this report are essentially a re-statement of information provided in the original Facilities Study for IR#516 and IR#517 performed by R.L. Johnson, P.Eng, in June of 2015. Final configuration of equipment and final costing has been inserted where appropriate.

2.0 SUMMARY:

This section provides an explanation of ownership and project costs for:

- Transmission Provider Interconnection Facilities (TPIF)
- Network Upgrades (NU).

2.1 Ownership:

Ownership, maintenance and other commercial operating arrangements will be covered separately in more detail in the Generator Interconnection and Operating Agreement between Nova Scotia Power, FORCE, and the Interconnection Customer.

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	For the purposes of this Facilities Study, the Point of Change of Ownership will be the cable termination at Generator Platform #4 from the FORCE 13.8kV Collection Circuit 'C' and the 5-way subsea hub, as shown on the single line diagram attached in Appendix A. IR #598 utilizes Generator Platforms 4 through 9, with each Platform connected in series via subsea cable. The communications between Nova Scotia Power and FORCE is via a licensed 900MHz radio utilizing a 75ft composite pole, antenna and associated radio and tele-protection equipment and a 48V DC Supply located in the 90N-FORCE Substation but owned by NSPI. Nova Scotia Power also owns the revenue metering system located in the FORCE Substation. This includes **dedicated** set of revenue metering class potential and current transformers (i.e. functionality not shared with any other purpose) certified by Measurement Canada for 3 element metering, the revenue meter, and all associated wiring Including the wiring to the communication cabinet in the Customer's control building.
2.2	**Estimated Costs:** The original estimated cost for Nova Scotia Power's work to provide a 69 kV interconnection at 37N-Parrsborro was $1,728,832.00 (HST excluded). The estimated cost of TPIF and NU were divided equally between Interconnection Requests IR#516 and IR#517 as follows. TPIF Estimate: $1,454,332 (HST excluded) Network Upgrades Estimate: $ 274,500 (HST excluded) TPIF Estimate for each IR: $ 727,166 (HST excluded) NU Estimate for each IR: $ 137,250 (HST excluded) Total: **$1,728,832 (HST excluded)**

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The detailed cost estimate provided in Appendix E: Project Cost Estimate (Nova Scotia Power Portion) was based on the scope of work outlined in Section 4.0 of this Facilities Study Report. Strict accounting of costs during the project insured an accurate split between TPIF costs and Network Upgrade costs.

The deposit supplied via FORCE on behalf of IR#516 and IR#517 to cover the estimated TPIF and NU costs was:

$1,759,882 + $228,275 HST = **$ 2,023,864**.

(Note that the deposit provided was based on a revised estimate prior to the execution of the Generator Interconnection and Operating Agreement)

2.3 Actual Final Costs:

The final cost for Nova Scotia Power's work to provide the 69 kV interconnection at 37N-Parrsborro was as follows:

TPIF Actual Costs:	**$1,402,630**	**(HST excluded)**
NU Actual Costs:	$ 268,182	(HST excluded)
Total Actual Cost:	$1,670,812	(HST excluded)

According to the GIA, Each IC that uses common **TPIF** is responsible to provide an equal capital contribution for the shared portion of TPIF. As IR #598 is the fourth project to utilize all the TPIF, it is responsible for 1/4 of the TPIF capital costs (1/4 x $1,402,630):

TPIF (516/517/542/598): **$ 350,658 (Plus HST) each**

As IR#517 was eventually withdrawn, only three projects are left to contribute to the remaining commissioning costs. IR#598 will therefore be responsible for 1/3 of the remaining commissioning testing which is

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estimated at $2,899 plus HST each. As such, a capital contribution totaling $350,658 + $2,899 + $53,033 (HST) = **$406,590** is required from IR#598 for the shared usage of the TPIF infrastructure and remaining commissioning.

Nova Scotia Power will not permit the connection of IR#598 to the grid prior to receipt of the executed GIA and secured funding from the Interconnection Customer in accordance with Article 11.5 of the Generation Interconnection Agreement.

3.0 DESIGN:

Nova Scotia Power was responsible for the engineering and drawing production for all aspects of the scope of work at 37N-Parrsboro described in **Section 4.0** of this report. This included the 69 kV additions; the protection and control design; the telecommunications systems between Parrsboro and FORCE, Parrsboro and Maccan, & Springhill and RAL; the new SCADA RTU at 37N-Parrsboro; and the review of Protection and Control design at the 90N-FORCE substation affecting the interconnection with NSPI's transmission system.

FORCE was responsible for the engineering design of the 90N-FORCE interconnection substation.

The Interconnection Customer is responsible for design of all aspects of the generating facility on the Interconnection Customer's side of the Point of Change of Ownership shown in Appendix A – Single Line Diagram of Interconnection Substation.

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4.0 WORK COMPLETED BY NOVA SCOTIA POWER:

4.1 NSPI Work Completed at 37N-Parrsboro Substation:

At the 37N-Parrsboro Substation, Nova Scotia Power supplied and installed all required primary equipment, protection & control and telecommunications equipment.

Nova Scotia Power reconfigured line connections at 37N-Parsborro to convert the operation of the existing 25kV line between 37N-Parrsboro and 90N-FORCE to 69kV in coordination with the associated upgrades at 90N.

4.1.1 Single Line & Primary Equipment:

The Single Line Diagrams for 30N-Maccan, 37N-Parrsboro, and 74N-Springhill substations showing the 69kV supply to 90N-FORCE are included in Appendix "B".

4.1.2 Civil Work & Structures:

The addition of the new 69kV line terminal in the 37N-Parrsboro Substation yard required a small expansion (approx. 600 m^2) to the existing substation area. The following is a list of the structures that were added complete with associated concrete foundations:

a) 1- 69/138 kV Circuit Breaker
b) 2- 69/138 kV disconnect switch structures
c) 6- 69/138 kV bus support structures
d) 1- 3-ph 69kV Revenue Metering Combo PT/CT support structure
e) 1 – 3-ph Lightning Arrester support structure
f) 1- 1-phase PT support structure
g) 1- 3-phase PT support Structure

System	Description

h) 1- Control Building and associated trench/conduit to new equipment in the substation yard
i) Radio Tower

4.1.3 Primary Equipment

The following is a list of primary equipment added to the 37N-Parrsboro Substation

a) 1- 138kV, 1200A, 650kV BIL, SF^6 circuit breaker
b) 2- 138kV, 1200A, 350kV BIL, Alum Vertical Break Disconnect Switches (1 with integral ground disconnect)
c) 3 - 69kV 1-phase Revenue Metering PT/CT combo units
d) 3 - 60kV (48kV MCOV) Station Class Lightning Arresters
e) 3 - 69kV Bus PTs
f) 1- 69kV Line PT

4.1.4 Protection & Control:

Protection and control modifications were completed at the following substations: 90N-Force; 37N-Parrsboro; 30N-Maccan; & 74N-Springhill.

1.0 90N-Force Substation

1.1 The 90N-Force Substation was designed by Strum Engineering. Strum Engineering provided a transmission line protection scheme at the 90N-Force Substation terminal to match the protection scheme at the 37N-Parrsboro terminal.

1.2 The tele-protection facility installed at the Force Substation provides line differential, transfer trip and permissive trip to 37N-Parrsboro, and breaker status to 37N-Parrsboro, 30N-Maccan and 74N-Springhill. The

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facility is available to receive transfer trips from Parrsboro, Maccan and Springhill.

1.3 A SCADA/RTU facility was installed to provide metering, control and alarm information to NSPI's Ragged Lake Control Centre (ECC).

2.0 37N-Parrsboro Substation

2.1 Protection for Line L-5582 to the Force Substation was provided by a line differential relay SEL-311L. The 311L relay provides current differential protection, distance protection, directional overcurrent protection, metering and reclosing of the transmission line L-5582. A SEL-311C relay was provided as the backup protection relay. One panel serves as the line protection and breaker control panel.

2.2 Protection for Line L-5550 to Maccan at the Parrsboro terminal includes the tap transformer 37N-T51. An SEL-311C relay was installed to provide distance and directional neutral overcurrent protection looking towards the Maccan terminal. With the tap transformer located next to the line terminal, the zone 1 distance protection may operate on faults inside the transformer to trip the breaker and this may not coordinate with the transformer high side fuse. The zone 2 protection shall only be operated in time delayed mode and not the permissive overreach scheme. Another distance protection relay (SEL-311A or GE-D30) was provided as the backup protection.

2.3 A new panel was provided for L-5550 protection.

2.4 An islanding protection scheme was installed at Parrsboro to transfer trip the Force generation when the 69 kV breaker 37N-582 is opened at Parrsboro. The islanding and reclosing logic utilizes the status of the 90N-Force Substation breaker.

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2.5 A tele-protection facility was installed at the Parrsboro Substation to provide line differential, transfer trip and permissive trip channels to the Force Substation and transfer trip and permissive trip (for future 138 kV upgrade only) to the Maccan Substation.

2.6 An RTU was provided for metering, control, alarm and indication for the substation.

2.7 Three PTs at the L-5550 terminal and one PT at the Force line terminal were installed.

2.8 SCADA metering was added to L-5582, including accumulated energy (mwhr & mvahr), that also provides back up to the revenue metering.

3.0 30N-Maccan Substation

3.1 The L-5029 line protection panel P-10 was modified to replace the existing overcurrent relays with a SEL-311C relay and a SEL-311A relay to match the protection relays at Parrsboro.

3.2 The distance scheme operates as step distance with no permissive overreach function and adds torque control overcurrent to coordinate with the high side fuse of the transformer at Parrsboro.

3.3 An islanding protection scheme was provided to transfer trip the Force generation when the L-5550/L-5029 breaker 30N-529 is opened. The islanding logic utilizes the status of the Force Substation breaker.

3.4 The tele-protection facility was upgraded at the Maccan Substation to provide transfer trip and permissive trip (for 138 kV upgrade) to the Parrsboro Substation.

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3.5 A Kirk key interlock scheme was installed for the by-pass disconnect switch 30N-558 c/w electrical contacts for use in the event that breaker 30N-529 is out of service for maintenance. The islanding protection for 30N-529 shall be transferred to 30N-548 when 30N-558 by-pass switch is closed and Switch 30N-559 is open to provide for breaker maintenance on 30N-529.

3.6 A Kirk key interlock scheme was provided for the by-pass disconnect switch 30N-579 c/w electrical contacts for use in the event that Parrsboro 69 kV bus is fed from 74N-Springhill. The islanding protection for Maccan 30N-529 breaker shall be transferred to the Springhill breaker 74N-511 when the by-pass switch 30N-579 is closed.

3.7 A new line PT was installed at the L-5550 line terminal for the auto-reclosing of breaker 30N-529.

4.0 74N-Springhill Substation

4.1 An Islanding protection scheme was installed at the L-5029 protection panel to transfer trip the generation at the Force Substation when the by-pass switch 30N-579 is closed. Breaker status from the Force Substation and the status of the by-pass switch 30N-579 at Maccan are available at Springhill.

4.1.5 Communications:

Nova Scotia Power established a communication link between the 90N-FORCE Substation, 37N-Parrsboro, and NSPI's Energy Control Center at Ragged Lake via NSPI's existing radio site at Kirkhill as described in appendix "F". These communication links serve both SCADA and teleprotection requirements.

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4.2	**NSPI Work Completed at 90N-FORCE Substation** a) Installation and commissioning of telecommunications equipment (including tower, antenna, feed line and the communications cabinet) b) Installation of a dc supply to communications cabinet. c) Wiring and installation of revenue meters by NSPI Meter Services.
4.3	**NSPI Work Completed at 30N-Maccan** a) Installation of line 69kV PT & PT junction box b) Line L-5550 Protection Panel modifications c) Installation of Kirk interlocks on bypass disconnect switches 30N-558 and 30N-579
4.4	**NSPI Work Completed at 74N-Springhill** a) L-5029 Protection Panel Modifications.
5.0	**SCOPE OF WORK COMPLETED BY FORCE:**
5.1	**Single Line Diagram** A customer supplied preliminary single line diagram of the 90N-FORCE Substation is provided in Appendix "A".
5.2	**Permits, Approvals & Standards** The customer facilities are subject to the minimum requirements of the latest edition of the Canadian Electrical Code, CSA C22.1, for the purpose of

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wiring inspection. The cost associated with acquiring a wiring permit and the associated electrical inspections by Nova Scotia Power, were the responsibility of FORCE. An overview of the Inspection Authority requirements in Nova Scotia are outlined below:

- Nova Scotia utilities perform inspections in approximately 99% of the province
- Electrical Inspection Act requires that electrical work be performed under permit.
- Contractors must take out permits for work at voltage levels below and above 750V – including work on customer owned substations.
- Plans must be submitted for review and all equipment must be approved by a Recognized certification authority (CSA, ULC, etc.)
- Lead times – inspection service level is < 5 days from request – normally manage < 3 Days.
- No equipment will be connected or energized without authorization of the inspector.
- HV contractors need to be reminded about CEC requirements – Should arrange a meeting with the inspection authority at the appropriate time. (Andrew Pottier, 428-6684).

5.3 Transmission Line

The transmission line between Parrsboro and 90N-FORCE was built to 138kV standards and originally operated as a 25kV express feeder. In order to accommodate IR#516 and IR#517, the supply was upgraded to 69kV via the addition of a 69kV bay and breaker at the Parrsboro substation (37N).

5.4 Interconnection Substation

The complete layout and electrical design of the FORCE Interconnection Substation was the responsibility of FORCE, including the revenue metering.

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5.5 SCADA at 90N-FORCE

FORCE has provided sufficient RTU capability at 90N to accommodate all of NSPI's required data, status information, alarms and control points listed below.

Implementation Details:

NSPI's method for exchanging this data is through a serial link between our RTU and the Control System, using the DNP3 protocol.

Serial Configuration:

NSPI's standard serial configuration is 9600 baud, 8 bits, no parity and 1 stop bit.

DNP3 Configuration:

NSPI's RTU is configured as a DNP3 Master, Master Address 1. The Control System end of the link is configured as a DNP3 Slave.

Event classes:

Object	Event Class
Binary Input	1
Analog Input	2
Accumulator (Counter) Input	3

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At the 90N-FORCE Substation, FORCE provided SCADA control and indication to Nova Scotia Power Energy Control Centre via the radio communications system for the following;

a) Command for orderly shutdown of IC generation (limit to zero MW generation) via single instruction to 90N-FORCE

b) Command to permit curtailment to 1/3 Generation MW capacity via single curtailment instruction to 90N-FORCE

c) Command to permit curtailment 2/3 Generation MW capacity via single curtailment instruction to 90N-FORCE

d) Command to permit full generation MW capacity (allow full MW output) via single curtailment instruction to 90N-FORCE

e) Status of Generation output limiting with regards to above four (4) MW limits

f) Control, Alarms & Status of breaker 90N–551;

Scada Breaker Control:

- Breaker 90N-551 Close and Trip

Local Control (SCADA) initiated by the following device:

- Breaker in Local control

Non-Urgent (SCADA) initiated by the following device:

- Breaker 90N-551 Gas Monitor Trouble

Breaker 90N-551 Urgent (SCADA) initiated by the following devices:

- Breaker 90N-551 SF6 Density Low
- Breaker 90N-551 Motor Overload

System	Description

- Breaker 90N-551 Trip Circuit Failed

Breaker 90N-551 Control Lockout (SCADA) initiated by the following device:

- Breaker 90N-551 SF6 Control Blocked

Scada Breaker Indication:

- Breaker 90N-551 SCADA Closed indication

g) Status of all 13.8kV breakers

h) Individual Berth holder watts, vars, watt-hours, var-hours, voltage

i) 90N-FORCE total watts, vars, watt-hours, var hours, voltage

j) Pf set point control at the FORCE 13.8kV bus

k) Individual Berth holder communication link status

It is to be noted that the above SCADA listings represent the minimum requirements consistent with all IPPs. Any subsequent agreement between NSPI and FORCE for the operation of the 90N FORCE Substation may impact these requirements.

6.0 SCOPE OF WORK BY INTERCONNECTION CUSTOMER:

6.1 Interconnection Facilities

The Interconnection Customer is responsible for the design and construction of all required interconnection facilities necessary to connect their tidal platforms to the 90N-FORCE facility.

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6.2	**Permits, Approvals & Standards** The Interconnection Customer is responsible for acquiring all necessary permits and approvals for the installation of their in-stream tidal generator arrays, and for complying with the applicable standards for the design and construction of their interconnection facilities (ref Section 5.2).
7.0	**REVENUE METERING**: NSPI has installed revenue metering at the Point of Interconnection (37N-Parrsboro Substation). At 90N-FORCE, revenue metering is required for each individual berth holder connected to the 13.8kV switchgear as well as the station service supply. The facility for remote interrogation of the revenue meters shall be provided by the FORCE. At the 90N-FORCE Substation, Force has supplied and installed the required Measurement Canada approved revenue metering PTs and CTs, and associated raceways and meter mounting facilities. Nova Scotia Power's Meter Services Group has installed the wiring to Nova Scotia Power specifications including color coded wiring and test switch as per Nova Scotia Power metering standard STD **5.12** herein attached as Appendix C: Revenue Metering. NSPI Meter Services have approved the panel mounted ION 7650 meters that are existing on the switchgear for each berth holder. The bus PTs that are currently on the 13.8kV bus in the switchgear line up are used for local metering and protection. A dedicated set of PTs has been added for the purpose of revenue metering.

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	Nova Scotia Power & FORCE collaborated on the final design of the revenue metering approach given that the POI is at 37N-Parrsboro and the individual berth holders are metered at 90N-FORCE.
8.0	**COMMISSIONING:** The following commissioning activities were undertaken with IR#516 and IR#517: ▪ At the 37N-Parrsboro Substation, Nova Scotia Power have performed the necessary primary and secondary commissioning of all protection, control, metering, telecommunications, and SCADA modifications. ▪ At the FORCE substation, FORCE has performed the commissioning on all primary and secondary equipment including the revenue metering PTs and CTs. ▪ Joint verification of the communications medium and terminal equipment between the IC's interconnection substation and Nova Scotia Power's communications facilities was completed. In addition to the tasks listed above, Nova Scotia Power has reviewed; ▪ The insulation test results of the Customer's 138 kV circuit breaker, revenue metering PTs / CTs and the substation HV disconnect switch. ▪ The relay settings, relay test results and injection test results associated with the interconnection protection. ▪ Secondary commissioning and trip test results for interface protection, control and metering systems that interface to the Nova Scotia Power transmission system.

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- The final trip tests of interface protection

These reviews ensured that the FORCE substation was ready to be energized and accepted onto the system. Nova Scotia Power's Meter Services tested and confirmed the revenue metering being installed in the IC's substation including communications providing AMR (Automatic Meter Reading) back to Halifax via the new radio communications link.