ENMAX No.7 Substation 138/25 kV Transformer Upgrade

Functional Specification

APEGA Permit-to-Practice P-8200

(Project Number 1787)

Issued to

ENMAX Power Corporation. TFO (as the **legal owner** of a **transmission facility**) and

ENMAX Power Corporation. DFO (as the **market participant**)

September 5, 2017

Version V2

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Functional Specification Revision History

Revision	Description of Revision	By	Date
V1D1	• For Comments	Yaoyu Huang	October 27, 2016
V1	• For Issuance	Yaoyu Huang	November 21, 2016
V2	• Section 5.3 updated • Transformer capacity description updated • SCADA adding GPS requirement for RTU • For Issuance	Yaoyu Huang	September 5, 2017

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1 PURPOSE

(1) The purpose of this document (the “Functional Specification”) is to set out the technical specifications and requirements and approved variances issued by the AESO to the **legal owner** of a **transmission facility**, ENMAX Power Corporation TFO., and the **market participant** and the **legal owner** of the **electric distribution system**, ENMAX Power Corporation DFO., related to the design, construction, development and commissioning of certain new or modified facilities (the “Project”) that have been proposed for or are related to a physical facilities connection with the **interconnected electric system** (the "Purpose").

(2) This Functional Specification is issued for the Purpose only, and the **legal owner** of a **transmission facility** and the **market participant** must comply with the Functional Specification provisions.

(3) The AESO is not responsible for any facilities designed by or for any third party, or installed on a third party’s behalf, to accomplish the connection of the Project facilities.

(4) This Functional Specification includes:

(i) certain specific engineering, technical and functional requirements for the Project;

(ii) the requirements to comply with **ISO rules**, Operating Policies & Procedures (OPPs), **reliability standards**, technical standards, and **ISO tariff** provisions, (collectively the “Authoritative Documents”);

(iii) the electrical system environment in which the connecting facilities must be designed and operated; and

(iv) any approved variances from requirements set out in any applicable AESO Authoritative Documents.

2 INTERPRETATION AND VARIANCES

(1) Subject to subsection (2), any revision or variance to any of the Functional Specification provisions by the **legal owner** of a **transmission facility** or the **market participant** is prohibited.

(2) The **legal owner** of a **transmission facility** or the **market participant** may make application, jointly or individually, in writing to the AESO requesting a variance to this Functional Specification, and the AESO may in writing approve of the variance after the AESO has completed an analysis of the implications to the interconnected electric system (AIES) with respect to the requested variance.

(3) Words or phrases appearing in bold have the meanings set out in the AESO *Consolidated Authoritative Document Glossary*.

3 PROJECT OVERVIEW

The **market participant** submitted a **system access service** request (SASR) to the AESO to reliably supply growing demand for electricity in the City of Calgary area. The City of Calgary area is located in the AESO transmission planning area of Calgary (Area 6). The **market participant**’s request can be met by upgrading the existing ENMAX SS-7 substation[1], including

[1] The SS-7 substation is also referred to as the No. 7 Substation.

replacing the two existing 138/25 kV transformers with two 138/25 kV transformers of higher capacity and adding one 138 kV circuit breaker, and associated equipment.

The **market participant**'s request includes a Rate DTS, *Demand Transmission Service*, contract capacity increase at the existing SS-7 substation of 5 MW, from 35 MW to 40 MW.

The scheduled in-service date (ISD) for this project is December, 2018.

4 FORECAST OF FUTURE DEVELOPMENT IN THE PROJECT AREA

Proposed long term developments in the Calgary area (Area 6) are described in the AESO 2015 Long-term Transmission Plan. Please refer to the AESO's website (www.aeso.ca) for more details of the long term transmission developments in the area.

5 SCOPE OF WORK

5.1 General

(1) The **legal owner** of a **transmission facility** and the **market participant** must complete all engineering, design, land or land-use acquisition, siting, public consultation, applicable regulatory approvals and permits, material procurement, construction, commissioning, and associated permitting requirements for the Project facilities.

(2) The **legal owner** of a **transmission facility** and the **market participant** must coordinate with each other as required on all project facility design details, including protection and control, telecommunication, grounding, insulation, **point of connection**, site layout, with proper considerations of maintenance coordination.

(3) The **legal owner** of a **transmission facility** and the **market participant** must develop joint operating procedures and any connection agreements as required such that all connecting **transmission facilities** will operate safely and reliably.

(4) The **legal owner** of a **transmission facility** and the **market participant** must deliver to the AESO all final design and as-built Project facility information and records in the format and content required by the AESO, to enable the AESO to update and maintain its transmission technical records and system models.

(5) The **legal owner** of a **transmission facility** and the **market participant** must submit the project information and records referred to in subsection (4) above, under the professional stamp and signature of a registered professional engineer in Alberta who assumes responsibility for the preparation and accuracy of the content of the information and records.

(6) The **legal owner** of a **transmission facility** and the **market participant** must mutually agree on each party's roles and responsibilities regarding inspection of all facilities of the Project prior to energization of the facilities.

(7) The **legal owner** of a **transmission facility** and the **market participant** must ensure that all Project facilities have been inspected by qualified personnel in accordance with industry standards and practices, so that the project facilities are declared to be:

(a) safe for operation; and

(b) in compliance with this Functional Specification, Alberta Reliability Standards and any Authoritative Documents for which the Project must comply

(8) No Project facilities are to be energized until an energization authorization has been issued by the AESO in accordance with the **ISO rules**.

5.2 Compliance with AESO Authoritative Documents

The **legal owner** of a **transmission facility** and the **market participant** must comply with the Authoritative Documents provisions which are applicable to the Project and which requirements must be satisfied and incorporated in to the design, construction, development and operation of the connecting facilities and other connection Project work, including but not limited to those provisions contained herein:

- AESO Operating Policies and Procedures
- Alberta Reliability Standards
- AESO Measurement System Standard Rev. 1 (dated September 18, 2007)[2]
- **ISO rules** including:
    - Section 502.3, Interconnected Electric System Protection Requirements (effective August 30, 2016);
    - Section 502.4, Automated Dispatch and Messaging System and Voice Communication Systems Requirements (effective March 27, 2015);
    - Section 502.8, SCADA Technical and Operating Requirements (effective March 27, 2015);
- AESO Generation and Load Interconnection Standard (dated September 19, 2006) [2].

5.3 Modeling Data Requirements

All modeling data shall be provided as per the Information Document ID# 2010-001R Facility Modelling Data (issued March 23, 2017), which relates to Section 502.15 of the **ISO rules**, *Reporting Facility Modelling*.

5.4 Substation Equipment Specifications

All new substation equipment[3] must meet the following minimum specifications:

- Temperature rating of -50ºC for all outdoor equipment.
- Equipment maximum and minimum continuous voltage ratings as indicated in Table 5
- Minimum continuous equipment current ratings as indicated in Table 1.
- Equipment maximum fault duty: 31.5 kA for 138 kV.

Table 1. Minimum Continuous Equipment Current Ratings (A)

Component note 5	**138kV**
Main Bus Note 1	1200
Cross Bus Note 2,3	600
Equipment or line terminal Note 4	600

[2] The AESO considers this standard to remain in effect notwithstanding the statement in clause 1.5 of this standard.

[3] Equipment includes such items as the power transformer, circuit breaker, capacitor bank, shunt reactor, high voltage current transformer, potential transformer, bus work, air break, and switchgear.

Notes for Table 1:

Note 1: Main bus includes all sections of ring bus scheme or single bus of simple bus or breaker and a half scheme except the portion of the bus connecting to a transformer.
Note 2: Cross bus includes diameter sections of breaker and a half or breaker and third schemes.
Note 3: Cross bus can have higher minimum current rating based on bus configuration and equipment connectivity
Note 4: Line terminal includes all equipment and conductor from the transmission line to the line breakers.
Note 5: Current rating of the equipment below 69 kV within the substation shall be determined by the **legal owner** of a **transmission facility**, in consultation with **market participants**.

5.5 Specific Scope of Work for the Legal Owner of a Transmission Facility

(1) General Requirements

- Coordinate with the **market participant** to develop necessary connection agreements and joint operating procedures.
- Ensure project safety is appropriately managed from design through energization.
- Undertake all required grounding studies, testing and mitigation as required for electrical safety.
- Complete grounding studies, testing and mitigation for electrical effects on communication systems.
- Complete insulation coordination studies and coordinate with the **market participant** as required to establish appropriate insulation levels.
- Any lines from one bus terminal to remote bus terminal should not have any terminal equipment that de-rates the minimum line capacity specified by the AESO.
- All site preparation, fencing, foundations, grounding, support structures, termination structures, duct work, cabling, bus work, station service, control building, protection, controls, etc. as required.

(2) SS-7 Substation – See Appendices 7.2.1 & 7.2.2

Substation Major Equipment

- One (1) 138kV bus tie breaker
- Two (2) 138kV disconnect switches for the bus PTs.
- Two (2) 138/25 kV LTC transformers, each with a transformation capability of 45 MVA [4].
- Discontinue from use for transmission purpose for the existing two (2) 138/25 kV 18/24/30 MVA transformers 7.1TR and 7.2TR

[4] The **legal owner** of the **transmission facility** selects transformer rating, in consultation with the **market participant**, to meet the current load requirement, load forecasting, and taking into account the ratings of its fleet of transformers.

Protection and Control

- Complete system protection coordination studies and coordinate with the **market participant** as required to establish settings appropriate for the facility additions and Alberta Interconnected Electric System (AIES) operations.
- Install all the required protection and control equipment to accommodate the new facilities addition.
- Review, modify and/or upgrade the existing protections as required to accommodate the new connection and configuration.

SCADA

- Establish communications interface point such that SCADA data can be transmitted back to the AESO's System Coordination Center (SCC) and Backup Coordination Centre (BUCC).
- All new Remote Terminal Units (RTU) shall have Global Position System (GPS) for time synchronization.
- Implement control center data mapping and verification of SCADA information for the proposed transmission facility additions and modifications, and any associated changes required at other area substations as per **ISO rule** 502.8. A complete listing of energy data requirements can be found in Appendices 7.3 and 7.4 of this document.

Telecommunication

- Modify/upgrade the existing communication system as required and establish appropriate communication interface such that tele-protection, SCADA, operational voice, operational data and mobile radio requirements are met.

5.6 Scope of Work for Market Participant

(1) General Requirements

- Coordinate with the **legal owner** of a **transmission facility** to develop necessary connection agreements and joint operating procedures.
- Undertake all required grounding studies, testing, and mitigation to ensure the connecting to transmission facilities are safe.
- Ensure connection project safety is appropriately managed from design through energization.

6 TRANSMISSION SYSTEM OPERATING CHARACTERISTICS

The **legal owner** of a **transmission facility** and the **market participant** must ensure all facilities are capable of operating in the following electrical environment.

6.1 Short Circuit Current Levels

(1) The short circuit current levels set out in Tables 2, 3 and 4 have been developed by the AESO based on information provided by the **legal owners** of a **transmission facility,** any

connecting **generating units,** and adjacent operating areas. Available fault current levels will continue to increase as generation, transmission, and system inter-ties are added to the **interconnected electric system**. The **legal owner** of a **transmission facility** and market participant must continue to review the fault levels and their equipment ratings for adequacy.

(2) Any future equipment upgrades or protection system setting changes required due to increasing fault levels are the responsibility of the **legal owner** of a **transmission facility** or the **market participant**, as applicable.

(3) The following assumptions were incorporated into the AESO short circuit current models:

(i) All expected Alberta generation is dispatched.
(ii) All transmission elements are in service.
(iii) The proposed Project facility is connected as per this document.
(iv) $V_{base} = V_{bus}$, $MVA_{base} = 100$

Table 2: Summary of Short-Circuit Current Levels – Pre-Project (Year 2018)

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
SS-7	138	139.2	17.2	0.005955+j0.024288	12.7	0.008165+j0.050890
SS-36	138	139.1	18.3	0.006501+j0.022601	15.0	0.006255+j0.038732
	69	72.2	11.1	0.013932+j0.079488	10.8	0.007414+j0.086181
SS-14	138	139.3	16.3	0.007492+j0.025274	11.6	0.011100+j0.058128
SS-21	138	139.6	22.4	0.005372+j0.018483	19.5	0.004757+j0.027711
	69	72.1	14.2	0.010158+j0.061778	15.2	0.003950+j0.050977
Bearspaw 44S	138	139.0	17.1	0.007344+j0.024065	14.7	0.006304+j0.036679
Sarcee 42S	240	249.8	15.3	0.003686+j0.016351	14.0	0.002569+j0.021499
	138	139.6	27.8	0.004242+j0.014928	28.0	0.001711+j0.015288

Table 3: Summary of Short-Circuit Current Levels – Post-Project (Year 2018)

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
SS-7	138	138.9	17.2	0.005976+j0.024249	12.7	0.008166+j0.050884
SS-36	138	138.8	18.3	0.006508+j0.022569	15.0	0.006254+j0.038725
	69	72.1	11.0	0.013928+j0.079458	10.8	0.007414+j0.086174
SS-14	138	139.1	16.3	0.007493+j0.025245	11.6	0.011098+j0.058115
SS-21	138	139.3	22.4	0.005367+j0.018457	19.5	0.004755+j0.027694
	69	72.0	14.2	0.010152+j0.061751	15.2	0.003949+j0.050968
Bearspaw 44S	138	138.8	17.1	0.007348+j0.024036	14.7	0.006304+j0.036672
Sarcee 42S	240	250.0	15.3	0.003692+j0.016380	13.9	0.002576+j0.021551
	138	139.5	27.8	0.004241+j0.014908	28.0	0.001714+j0.015289

Table 4: Summary of Short-Circuit Current Levels – Post-Project (Year 2026)

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
SS-7	138	139.3	19.9	0.004779+j0.020685	14.1	0.007791+j0.047126
SS-36	138	139.0	22.5	0.005022+j0.018036	17.8	0.005530+j0.033075
	69	71.6	12.0	0.012815+j0.071259	11.5	0.007065+j0.081028
SS-14	138	139.1	18.1	0.006499+j0.022372	12.7	0.010026+j0.052333
SS-21	138	139.6	28.8	0.004116+j0.014112	26.0	0.003272+j0.019231
	69	71.9	20.5	0.006743+j0.041903	22.9	0.002360+j0.029227
Bearspaw 44S	138	139.0	20.0	0.006114+j0.020214	16.7	0.006047+j0.033154
Sarcee 42S	240	251.6	21.9	0.002422+j0.011240	18.9	0.002664+j0.016961
	138	140.2	33.0	0.003366+j0.012453	33.3	0.001542+j0.012467

The AESO acknowledges the short circuit current levels in Sarcee 42S identified in the table 4 which is approaching or exceed the equipment rating identified in section 5.4. The AESO will work with **market participants** to address this prior to this level being reached.

6.2 Voltage Levels

Table 5 provides the normal planned operating voltage range in the area of the proposed facility.

Table 5: Planned Operating Range

Substation Name and Number	Nominal Voltage (kV)	Emergency Minimum Voltage (kV)	Desired Normal Minimum Voltage (kV)	Desired Normal Maximum Voltage (kV)	Emergency Maximum Voltage (kV)
SS-7	138	124	135	145	150

Notes:

1. The Desired Normal Operating Minimum and Desired Normal Operating Maximum are generally associated with Category A events and system normal.
2. The Emergency Minimum Voltage and Emergency Maximum Voltage are generally associated with Category B and C events and system abnormal.
3. The facilities must be capable of continuous operation at voltages up to and including the Emergency Maximum Voltage.

6.3 Insulation Levels

(1) Table 6 provides the required basic insulation levels for the **transmission facilities**. Station equipment with lower insulation levels may be used provided that protection and coordination can be maintained with judicious insulation design and use of appropriate surge arresting equipment.

(2) For 25 kV circuit breakers where there is a grounded wye transformer and surge arrestors are installed a basic insulation level of 125 kV is acceptable

Table 6: Basic Insulation Levels (kV)

Nominal Voltage Classification (kV rms)	**138**
Station Post Insulators and Airbreaks	550
Circuit Breakers	650
Current and Potential Transformers	650
Transformer Windings (Protected by Surge Arresters)	550

6.4 Remedial Action Scheme (RAS)

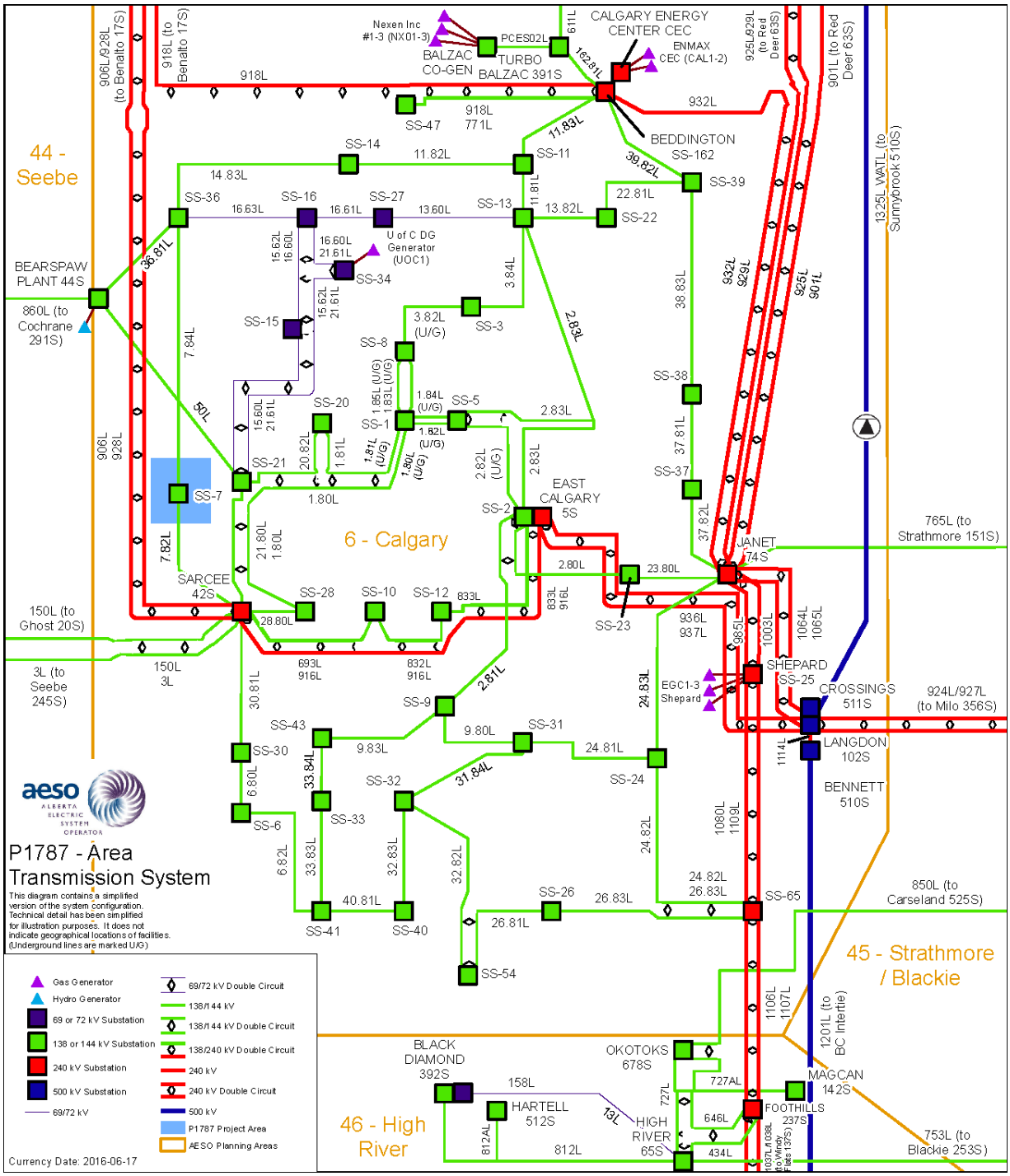
The Engineering Study Report (ESR) for this Project has indicated that no Remedial Action Scheme (RAS) or System Control Procedure (SCP) was identified for this Project based on assumptions used in the study.

Prior to the ISD of the Project, additional operations planning studies will be performed to determine and/or confirm the required mitigation measures, RAS, or procedure, by taking into account other connection and system projects, as appropriate. This will ensure that appropriate mitigation will be in place prior to the ISD of the Project. The AESO will consult with the **legal owner** of a **transmission facility** and the **market participant** before specifying revised and/or new mitigation measures.

7 APPENDICES

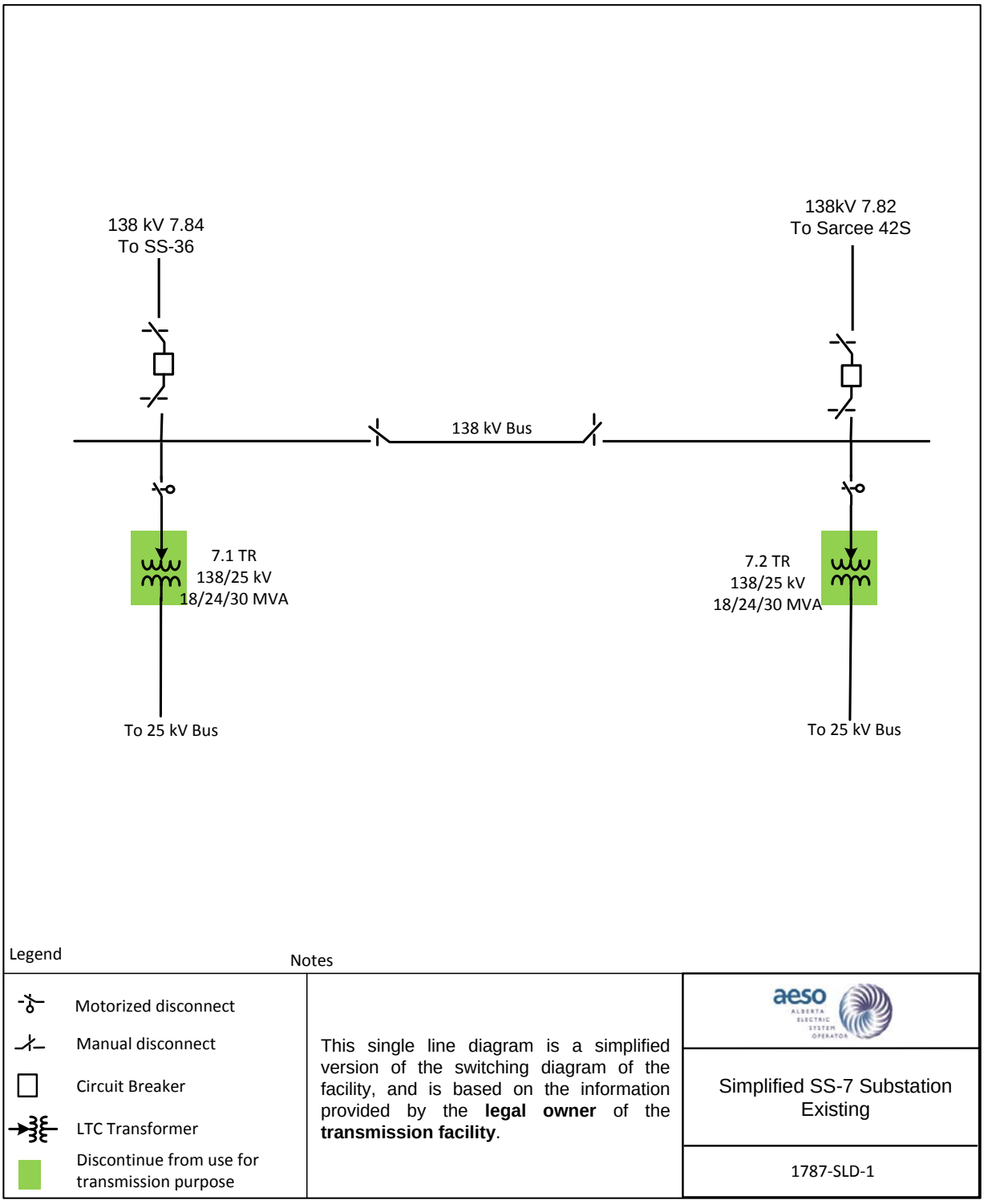
7.1 System Interconnection

7.1.1 System Interconnection – Existing and Proposed development

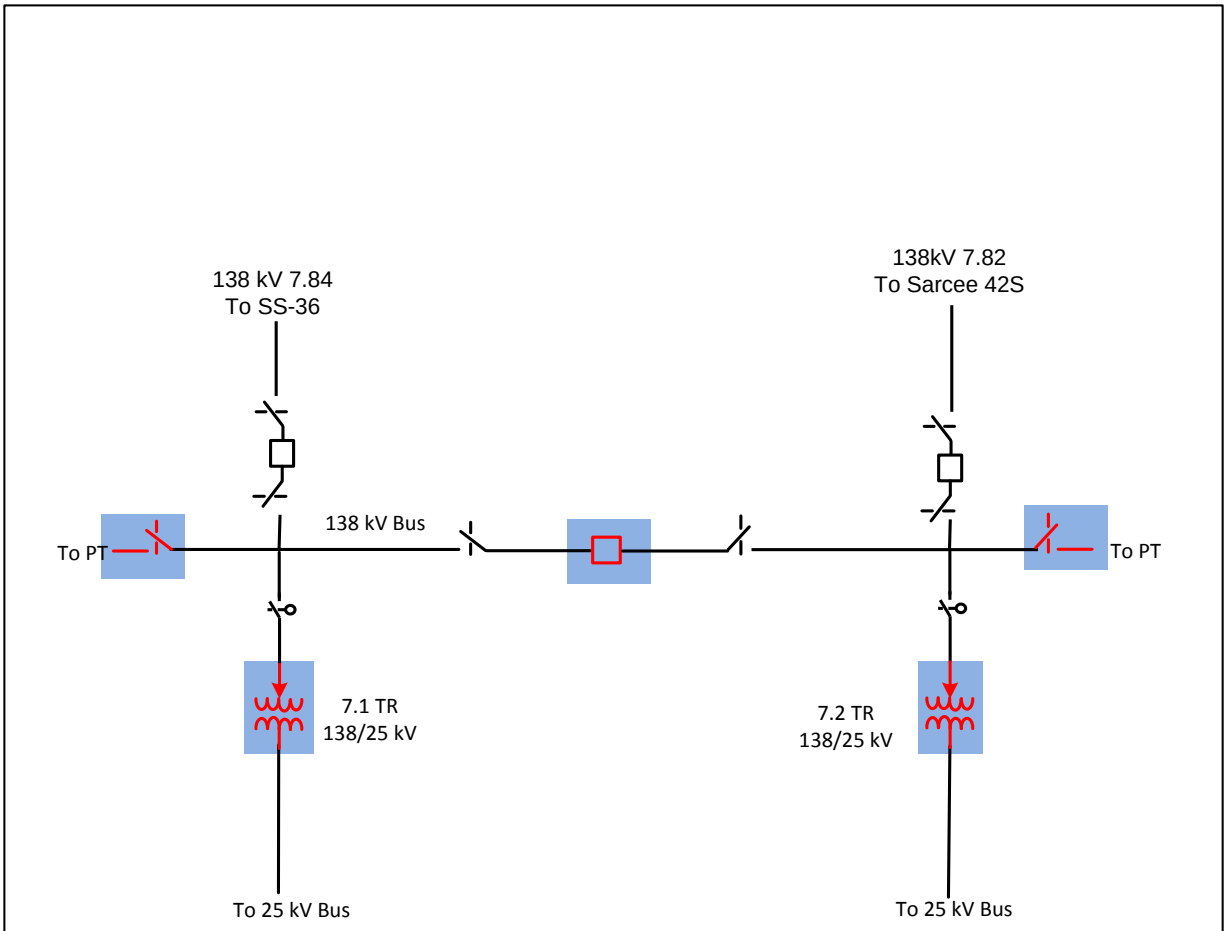


7.2 Single Line Drawing

7.2.1 Single Line Drawing – Existing SS-7 Substation



7.2.2 Single Line Drawing – Proposed SS-7 Substation Developments



Legend

- Motorized disconnect
- Manual disconnect
- Circuit Breaker
- LTC Transformer
- Proposed developments

Notes

*This single line diagram provides an illustration of a functional arrangement that would meet the need of the proposed project. Although the **legal owner** of the **transmission facility** is required to maintain the specified functionality, the exact routing and configuration of the project proposed by the **legal owner** of the **transmission facility** in its facility application may vary from this configuration based on more detailed engineering, routing and siting information obtained by the **legal owner** of the **transmission facility** in preparation of its Facility Application*

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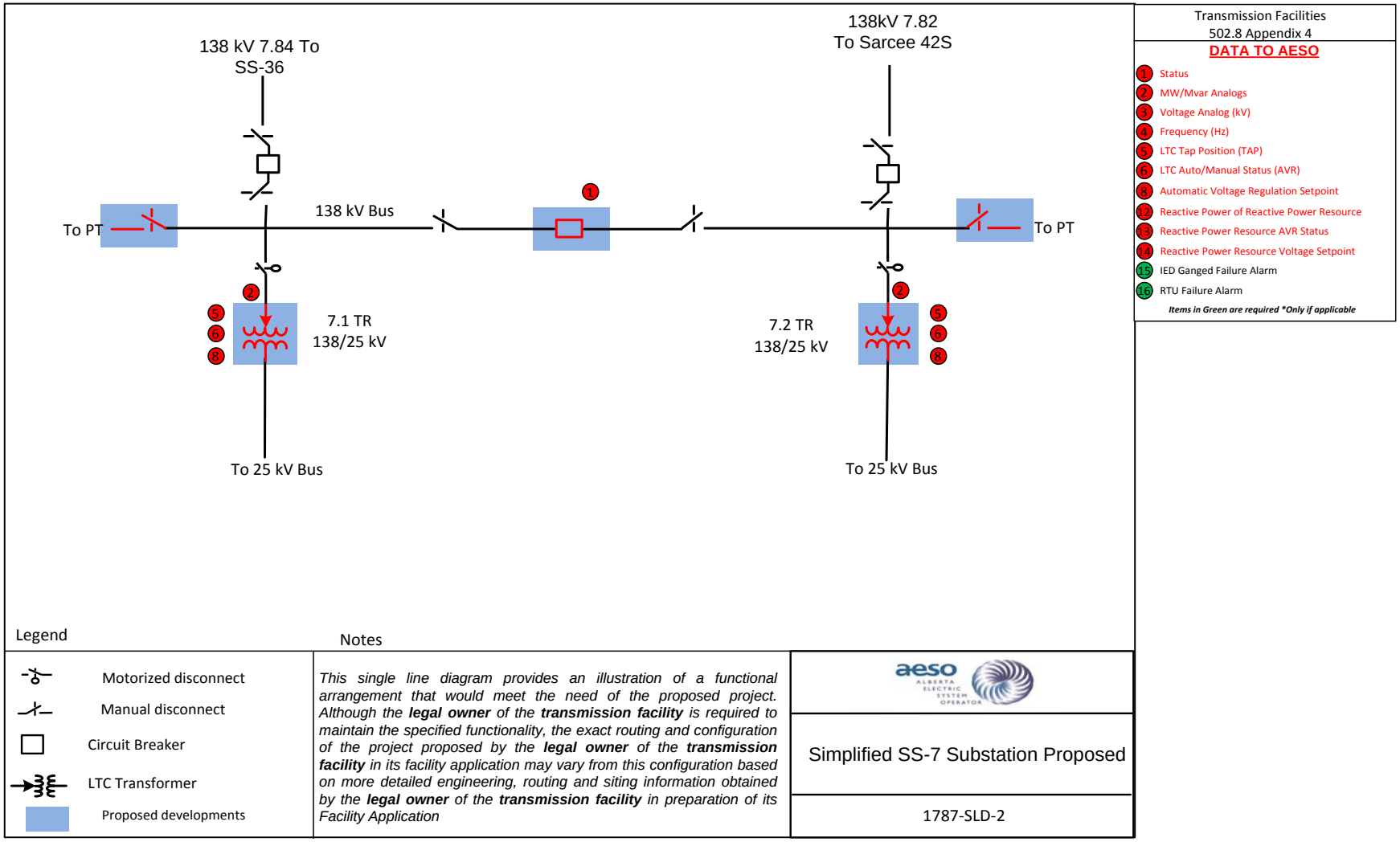
Simplified SS-7 Substation Proposed

1787-SLD-2

7.3 SCADA Requirements

7.3.1 SCADA Requirements for SS-7 substation



7.4 Static Data Requirements

Facility / Location	Device	Element	Indication	Update Rate/Mode	Notes
SS-7	138kV CB1	138KV bus tie breaker	Status	On Event	
	138/25KV LTC Transformer T1	T1 Load Tap Changer Auto/Manual State	Status	On Event	
	138/25KV LTC Transformer T2	T2 Load Tap Changer Auto/Manual State	Status	On Event	
	138/25KV LTC Transformer T1	T1 High Side Real power	MW	30s	
	138/25KV LTC Transformer T1	T1 High Side Reactive Power	MVAr	30s	
	138/25KV LTC Transformer T1	T1 Tap Position	Integer Value	30s	
	138/25KV LTC Transformer T1	T1 Automatic voltage regulation setpoint	kV	30s	
	138/25KV LTC Transformer T2	T2 High Side Real power	MW	30s	
	138/25KV LTC Transformer T2	T2 High Side Reactive Power	MVAr	30s	
	138/25KV LTC Transformer T2	T2 Tap Position	Integer Value	30s	
	138/25KV LTC Transformer T2	T2 Automatic voltage regulation setpoint	kV	30s	
Note	**1. MW and MVAr SCADA data shall be gathered independently of the revenue metering data**				
	2. This list was prepared using the best available information. Final SCADA point will be determined based on the applicable SCADA Standard (502.8)				