Crofton- Condensing Steam Turbine Generator Project

[redacted]

Interconnection System Impact Study

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Revision Table

Revision Number	Date of Revision	Revised By

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EXECUTIVE SUMMARY

[redacted] the Interconnection Customer (IC), proposes to develop the Crofton – Condensing Steam Turbine Generator project to provide increased load displacement power. This project will add a second generator inside the existing Crofton mill which is located about 9 km from Vancouver Island Terminal substation (VIT) on Vancouver Island, British Columbia.

This report documents the evaluation of the system impact of interconnecting the proposed generating facilities and identifies the required system modifications to obtain acceptable system performance with the interconnection of the proposed Crofton – Condensing Steam Turbine Generator project. This project is the addition of a 18.3 MVA generator (STG2). The new generator and the existing generator (STG1, rated 43 MVA) will be connected to two of the several 13.8 kV load busses within the Crofton mill (CFT) power distribution system. The Crofton mill's six 132/13.8 kV transformers are fed from the IC-owned 138 kV bus which in turn is supplied by two BC Hydro 138 kV circuits from VIT (circuits 1L139 & 1L140). The Point of Interconnection (POI) is at the CFT ends of the two lines 1L139 and 1L140. The maximum power injection to the BCH system is 0 MW because the mill's load will always be more than the combined power output from the two generators. The project's proposed Commercial Operation Date (COD) is February 1, 2018.

To interconnect the Crofton – Condensing Steam Turbine Generator project and its facilities to the BCH Transmission System at the POI, this System Impact Study (SIS) has identified the following conclusions:

- No equipment overload and voltage violation has been identified. No adverse impact to the dynamic behavior of the Transmission System has been identified.
- The customer will need to provide redundant (primary and standby) line protection on the CFT ends for multi-phase and single line to ground faults on each line (1L139 and 1L140).
- With the generator addition, the existing protection settings at VIT will need to be reviewed and revised.
- The non-binding good faith cost estimate for Interconnection Network Upgrades required to interconnect the proposed project to the BCH Transmission System is $ 118k. The cost for Revenue Metering is $51k, which is not included in the Network Upgrade cost.
- The estimated time to complete the Interconnection Network Upgrades is up to 6 months after project approval.

The Interconnection Facilities Study report will provide greater detail of the Interconnection Network Upgrade requirements and associated cost estimates and estimated construction timeline for this project.

TABLE OF CONTENTS

1.0 INTRODUCTION

The project reviewed in this Interconnection System Impact Study (SIS) report is as described in Table 1 below.

Table 1: Summary Project Information

Project Name	Crofton – Condensing Steam Generator Project	
Interconnection Customer	[redacted]	
Point of Interconnection	At the CFT ends of the 138 kV lines 1L139 and 1L140	
IC Proposed COD	February 1, 2018	
Type of Interconnection Service	NRIS ☒	ERIS ☐
Maximum Power Injection (MW)	0.0 (Summer)	0.0 (Winter)
Number of Generator Units	Two (1 new and 1 existing)	
Plant Fuel	Steam	

[redacted] the Interconnection Customer (IC), is an existing load customer located in southern Vancouver Island near Vancouver Island Terminal (VIT). The IC has a single unit co-gen (STG1 with rating 43 MVA) that supplies its own mill load. BC Hydro's abbreviation for the IC's station is CFT. There is no power export from CFT and historically BCH supplies the difference between the mill's load and co-generation.

Catalyst Paper proposes to add a second generator (STG2) inside the mill as additional load displacement. The IC will not export power into the transmission grid.

The Point of Interconnection is on 1L139 and 1L140, at the existing entrance gate to CFT, and 9 km from VIT.

Inside Crofton mill the two 13.8 kV generator units are designated as STG1 and STG2 with these major parameters:

	Rated MVA	Rated MW	PF (lag/lead)	
STG1	43	38.7	0.9 / 0.9	(existing)
STG2	18.3	16.5	0.9 / 0.9	(new)

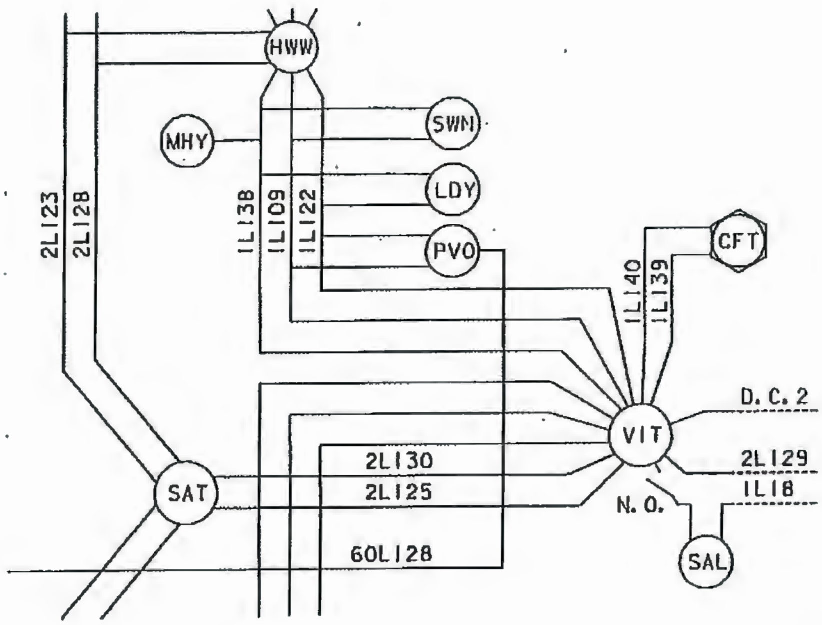


Figure 1 – CFT and local 230kV & 138 kV transmission system

Figure 1 above shows the IC's station CFT as well as the 230 kV & 138 kV systems in the VIT area.

Figure 2 below shows the geographic location of CFT in southern Vancouver Island.

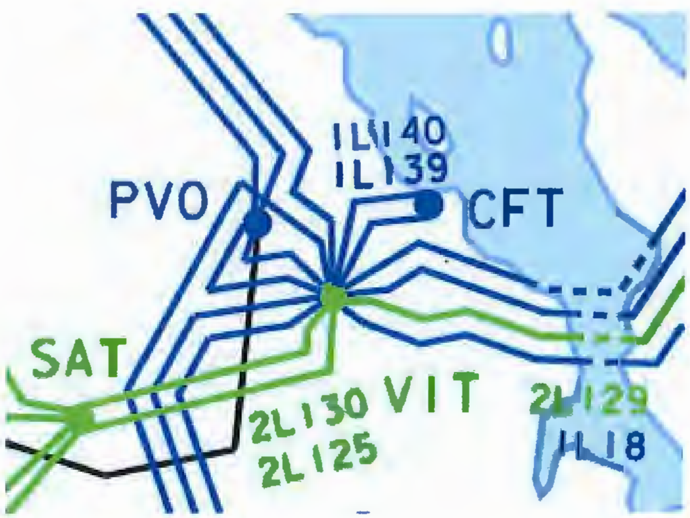


Figure 2 – Geographic Location of CFT load customer

2.0 PURPOSE OF STUDY

The purpose of this SIS is to assess the impact of the interconnection of the proposed project on the BCH Transmission System. This study will identify constraints and Network Upgrades required for interconnecting the proposed generating project in compliance with the NERC/WECC reliability standards and the BC Hydro transmission planning criteria.

3.0 TERMS OF REFERENCE

This study investigates and addresses the voltage and overloading issues of the transmission network in the vicinity of VIT as a result of the proposed interconnection. Topics studied include equipment thermal loading and rating requirements, system transient stability and voltage stability, transient over-voltages, protection coordination, operation flexibility, telecom requirements and high level requirements for local area protection schemes (LAPS). BCH planning methodology and criteria are used in the studies.

The SIS does not investigate operating restrictions and other factors for possible second contingency outages. Subsequent internal network studies will determine the requirements for reinforcements or operating restrictions/instructions for those kinds of events. Any use of firm or non-firm transmission delivery will require further analysis specific to the transmission service that may be requested later and will be reviewed in a separate study.

The work necessary to implement the network improvements identified in this SIS report will be described in greater detail in the Interconnection Facilities Study report for this project.

4.0 ASSUMPTIONS

The power flow conditions studied include generation, transmission facilities, and load forecasts representing the queue position applicable to this project. Applicable seasonal conditions and the appropriate study years for the study horizon are also incorporated. The 2017/18 heavy winter, 2018 heavy summer and 2018 light summer load flow base cases were selected for this study.

The study is based on the model and data information provided by the IC in the Generator Interconnection Data Form for this project. Additional assumptions are made to complete the study and the report, whenever such information is unavailable.

5.0 SYSTEM STUDIES AND RESULTS

Power flow, short circuit and transient stability studies were carried out to evaluate the impact of the proposed interconnection. Studies were also performed to determine the protection, control and communication requirements and to evaluate possible over-voltage issues.

5.1 Steady State Pre-Outage Power Flows

Pre-outage power flows were prepared to assess the impact of the proposed interconnection using three basic system load conditions:

1. 2017/18 winter peak load;
2. 2018 summer light load;
3. 2018 summer peak load;

and defined generation conditions.

The steady-state power flow studies indicated the following findings:

- no voltage violations are observed; and,
- no circuits overloaded before and after the proposed interconnection.

Table 2 below shows the power flow study results for the 2018 system normal condition. This study case has 2018 Light Summer load conditions with 164 MW CFT load, and 38.7 MW output from STG1 and 16.5 MW from STG2.

Table 2 – Power Flow Study Results – Pre-Outage Case

Voltages in per unit (pu) on 132 kV or 13.8 kV base; power flow P & Q in MW, Mvar					
VIT132	1L139 P, Q	CFT132 on 1L139	1L140 P, Q	CFT132 on 1L140	13.8 kV load bus voltages highest, lowest
1.055 pu	65.1, 20.4	1.046 pu	43.9, 13.8	1.048 pu	1.035 pu, 1.005 pu
STG1 voltage, and P, Q			STG2 voltage, and P, Q		
1.035 pu, 38.7 MW, 11.4 MVar			1.030 pu, 16.5 MW, 5.8 MVar		

Notes :

1. In the pre-outage case the loads' P & Q values and the operating conditions for the generators and the switchable shunt capacitors are approximate, based on data submissions for the study.

5.2 First Contingency Power Flows

Power flow based single contingency (N-1) studies have been conducted to check if the post-disturbance performance including bus voltage deviation and facility loading meets the planning criteria under different system load conditions including heavy winter, heavy summer and light summer.

The studies have indicated that there is no transmission equipment over-loading problem, and there are no voltage violation conditions due to the addition of the IC's project.

Table 3 below shows the contingency study results on the 2018 light summer load conditions and the generation outputs same as those used for Table 2.

Table 3 – Power Flow Study Results – after Single Element Contingency

case	Voltages in per unit (pu) on 132 kV or 13.8 kV base; power flow P & Q in MW, Mvar					
1L139 outage	VIT132	1L139 P, Q	CFT132 on 1L139	1L140 P, Q	CFT132 on 1L140	13.8 kV load bus voltages: highest, lowest
	1.055 pu	-----	0.999 pu	109.9, 30.5	1.041 pu	1.023 pu, 0.986 pu
	STG1 voltage, and P. Q			STG2 voltage, and P, Q		
	1.023 pu, 38.7 MW, 18.7 Mvar (at Q limit)			1.006 pu, 16.5 MW, 8.0 Mvar (at Q limit)		
1L140 outage	VIT132	1L139 P, Q	CFT132 on 1L139	1L140 P, Q	CFT132 on 1L140	13.8 kV load bus voltages: highest, lowest
	1.056 pu	109.5, 28.2	1.043 pu	-----	1.009 pu	1.035 pu, 0.997 pu
	STG1 voltage, and P. Q			STG2 voltage, and P, Q		
	1.035 pu, 38.7 MW, 16.6 Mvar (near Q limit)			1.014 pu, 16.5 MW, 8.0 Mvar (at Q limit)		

Notes :

1. In the outage cases the 13.8 kV synchronous motors are assumed to provide increased voltage support (MVars) by having exciters in voltage control mode

5.3 Transient Stability Study

A series of transient stability studies under various system operating conditions including the heavy winter case and the most severe light summer case have been performed. The model of the generating project was based on the IC's data submission plus any additional assumptions where the IC's data was incomplete or inappropriate. The models and data values of the IC's key components are shown in Appendix B.

There is no transient instability issue with N-1 contingencies due to the connection of the Crofton Condensing Steam Turbine Generator project. The swing center, based on the data submitted by the IC, is estimated to be inside the IC's facility. If the IC's generator(s), under some more severe conditions, does become unstable the IC must be able to detect the out-of-step condition and trip off the generator(s). Out of step protection is required at the IC's facilities and must be provided by the IC. BCH can provide apparent impedance versus time plots of stable and unstable swings if requested.

The transient stability study results for 2018 Light Summer are summarized in the following Table 4. The load conditions and the generation outputs at CFT are same as those used for Tables 2 and 3.

Table 4 – Dynamic Performance Results

Case	Contingency	3-phase fault location	Near-end fault clearing	Far-end fault clearing	STG1 & STG2 generators' performance	Comments (see also note 2 below)
1	1L139 VIT-CFT	1L139 near CFT132	6 cy	6 cy	acceptable	Small rotor angle swing
2	1L140 VIT-CFT	1L140 near CFT132	6 cy	6 cy	acceptable	same
3	2L129 ARN-VIT	VIT230	6 cy	6 cy	acceptable	same

Notes:

1. In the pre-outage case the loads' P & Q values and the operating conditions for the generators and the switchable shunt capacitors are approximate, based on data submissions for the study.
2. The same acceptable performance by the generators was seen in additional cases where the 13.8 kV synchronous motors were modelled as synchronous machines instead of with a typical industrial load simple representation. These motors' models, as synchronous machines, used an assumed inertia value. The approximate model for these large synchronous motors was adequate; the objective was only to show the effect of their voltage support in the period after the loss of one 138 kV supply line to CFT.

5.4 Analytical Studies

No unacceptable temporary or transient over-voltage issues were identified.

CFT, as a load station, has 132/13.8 kV transformers with star-grounded winding on the 138 kV side. For this generation project, the IC makes no change to the existing transformers.

The event that could cause stress to the VIT 138 kV line-end circuit breakers would be the tripping of one line 1L139 or 1L140 when the other is already open (maintenance or forced outage). The CFT station's voltage would stay near normal level and the mill's under-speed condition (load exceeds on-line generation) would cause repeated out-of-phase conditions across the VIT line-terminal's 138 kV circuit breakers. The voltage across these circuit breakers' open contacts would be at least twice the normal 138 kV system voltage. An unrelated VIT circuit breaker replacement project is in progress and these new line-terminal circuit breakers will have ratings suitable for this level of stress.

5.5 Fault Analysis

The short circuit analysis for the System Impact Study is based upon the latest BCH system short circuit model, which includes project equipment and impedances provided by the IC. The model included higher queued projects and planned system reinforcements but excluded lower queued projects. Thevenin impedances, including the ultimate fault levels at POI, are not included in this report but will be made available to the IC upon request.

BCH will work with the IC to provide accurate data as required during the project design phase.

5.6 Transmission Line upgrade requirements

There is no transmission line upgrade identified.

5.7 BCH Station Upgrades or Additions

No station upgrades or additions are identified for this project.

5.8 Protection and Control & Telecommunications

Protection

As a source of generation, the Crofton Mill (CFT) must provide protection and control facilities consistent with BC Hydro's "60 kV – 500 kV Technical Interconnection Requirements for Power Generators" (TIR). The customer will need to provide redundant (primary and standby protection) for multi-phase and single line to ground faults on each line (1L139 and 1L140) to the B C Hydro system.

With the generator addition project, the existing protection settings at VIT will need to be reviewed and revised.

Control

With the additional generation for load displacement purposes, Crofton Mill (CFT) will remain a load customer. According to the existing TIR there are no BC Hydro control requirements for this project. However, BCH is contemplating a revision of the existing TIR, which would require telemetry and indication points for all customers with parallel generation.

Telecom
Based on the information above on the control requirements, there is no need to add telecom facilities at this stage. There is already good digital cellular coverage at CFT for the metering circuits.

5.9 Islanding

When both 138 kV lines from VIT are open the CFT mill can operate as its own isolated island.

However, islanded operation of the CFT generators to supply other BC Hydro load stations is not arranged. If an inadvertent island with other nearby BCH customer load stations forms that island would quickly collapse due to the large load (CFT internal load) and generation unbalance.

5.10 Black Start Capability

BCH does not require the proposed project to have black start (self-start) capability. A black start capability is not applicable since the CFT generators will not be used as a supply to other BC Hydro load stations.

5.11 Cost Estimate and Schedule

The non-binding, good faith cost estimate for the Interconnection Network Upgrades is $118k. The cost for Revenue Metering is $51k, which is not included in the Network Upgrade cost. The Interconnection Facilities Study report will provide more detailed information of the cost estimates.

The estimated time to complete the Interconnection Network Upgrades is up to 6 months after project approval. A more detailed construction timeline will be provided in the Interconnection Facilities Study report.

6.0 REVENUE METERING

The IC shall show disconnecting means/key interlocking scheme on the line and load side of the metering equipment on its plant single line diagram for the Revenue Metering purpose in order to allow isolation of metering equipment.

Metering requirements for STG2:

Point-of-Metering	Upstream of the generator STG2
Voltage Transformers	2 x VTs (L-L) – 14,400 – 120 V; To be supplied by the IC
Current Transformers	2 x CTs- 800-5A; To be supplied by the IC

The Point of Metering (POM) shall have a dedicated communications line (landline or alternative technologies e.g. cellular, fiber optic, microwave, satellite etc. subject to BCH approval) available for revenue metering use only. The remote read load profile revenue metering should be in accordance with the BC Hydro Requirements for Complex Revenue Metering. The latest version of this document is published at BC Hydro webpage under Forms and Guides. The revenue metering responsibilities and charges (Power generator or PG and BCH) shall be in accordance with Section 10 (10.1 and 10.2). For details about the specific responsibilities, see table on pages.23-25.

Revenue class meters (main and backup) approved and sealed by Measurement Canada (MC) will be installed to register the energy delivered and received from the power generator. The meters will be supplied and maintained by BC Hydro. The main meter will be leased by BCH to the PG.

The CTs and VTs used on the metering scheme will be supplied by the Power Generator and should be of a model/type approved by Measurement Canada. A 2-element metering scheme with 2 CTs and 2 VTs connected L-L shall be used. The CTs and VTs must be pre-approved by BC Hydro's Revenue Metering Department. The revenue metering VT and CT secondary windings are not permitted to be shared with any other equipment therefore no other devices shall be connected to the revenue metering VT and CT secondary windings. BC Hydro's Revenue Metering department can be contacted via email: metering.revenue@bchydro.com.

Metering requirements for STG1:

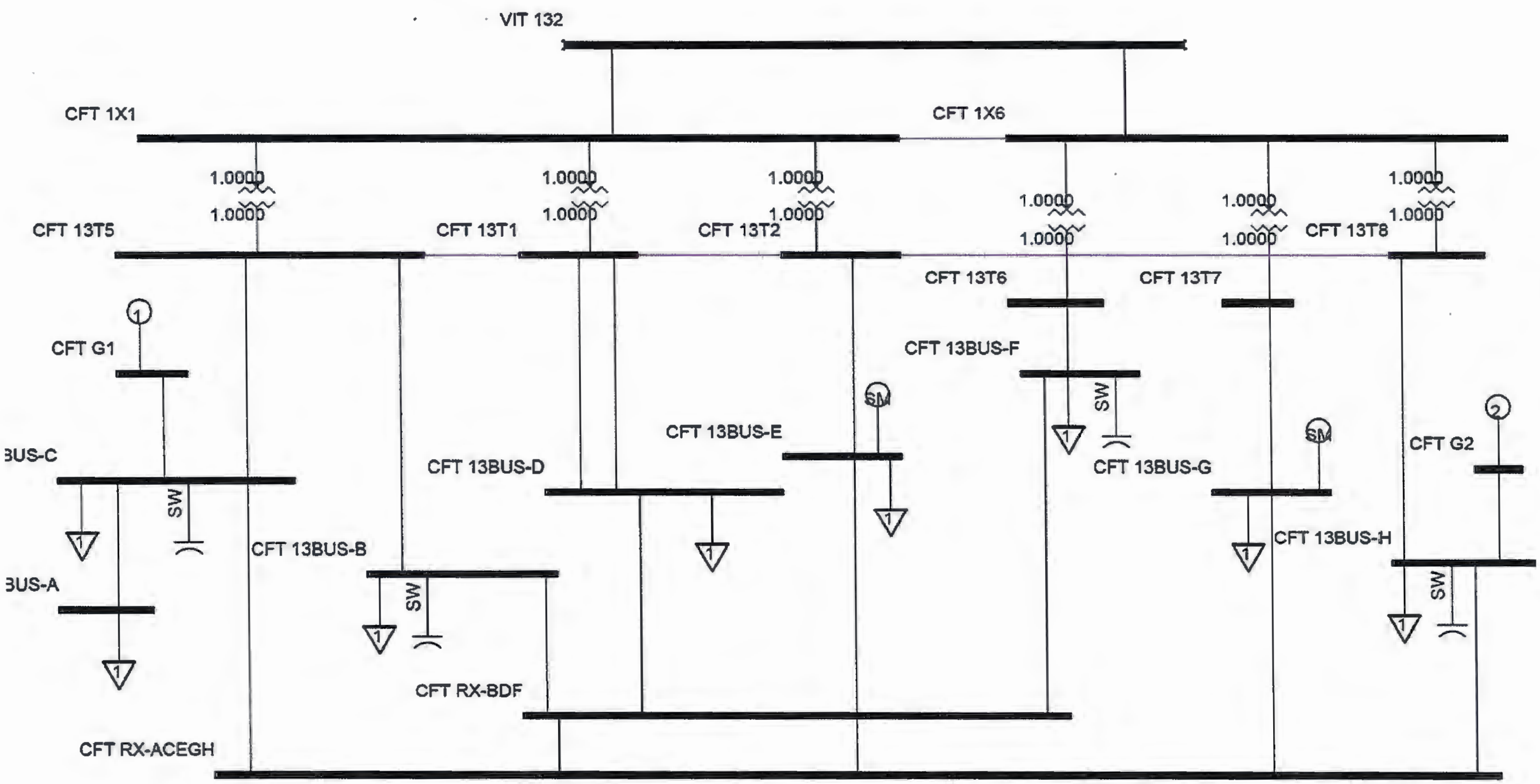
STG1 is an existing 43 MVA generator in the customer facility and has been in service over more than 10 years. An EPA or Interconnection Agreement (IA) for STG1 was never signed; therefore, Revenue Metering was never put in place for this generation. The IC has their own metering in place to monitor the generation output for their own needs. However, in order to meet Powersmart team's requirements, it was decided that the customer will upgrade their metering CTs/VTs to Revenue Class CTs/VTs and install a new revenue class meter with a dedicated communication line for BC Hydro so Powersmart team can download data for their own purpose. The metering CTs/VTs and the meter will be customer owned. Since there won't be an EPA for STG1, it was determined that Revenue Metering is not required, therefore, typical Revenue Metering requirements do not apply to STG1.

7.0 CONCLUSIONS & DISCUSSION

In order to interconnect the Crofton Condensing Steam Turbine Generator project to the BCH Transmission System at the POI, this SIS has identified the following issues and requirements:

- As a source of generation, the IC must provide protection and control facilities consistent with BC Hydro's "60 kV – 500 kV Technical Interconnection Requirements for Power Generators" (TIR). The customer will need to provide redundant (primary and standby) line protection for multi-phase and single line to ground faults on each line (1L139 and 1L140) to the B C Hydro system.
- With the generator addition project, the existing protection settings at VIT will need to be reviewed and revised.
- No additional unacceptable equipment overload conditions in the Transmission System were observed in the power flow analysis due to the Crofton Condensing Steam Turbine Generator Project under normal conditions and after N-1 contingencies.
- No additional unacceptable voltage violations in the Transmission System were observed in the power flow and transient stability simulations due to the Crofton Condensing Steam Turbine Generator Project under normal conditions and after N-1 contingencies.
- Out of step protection function is required at the existing generator STG1 and the new generator STG2 and will be provided by the IC.

APPENDIX A – Area Single Line Diagram with the IC Project



APPENDIX B – Power flow and Dynamic Models and Data

The key power flow and dynamic model data :

Generator Data

Generator	Rated MVA/MW	Base KV	Power Factor (lag/lead)	X_d	X"d
STG1	43 /38.7	13.8	0.9 / 0.9	1.74	0.22
STG2	18.3 /16.5	13.8	0.9 /0.9	1.85	0.185

Transformer Data

Transformer	Max Rating	Base MVA	Impedance (% on Base MVA)	Voltage (HV/LV Winding)	Connection HV	Connection LV
T-1	56	30	8.6	132 / 13.8	YG	YRG
T-2	56	30	8.7	132 / 13.8	YG	YRG
T-5	56.1	30	8.7	132 / 13.8	YG	YRG
T-6	25	15	8.63	132 / 13.8	YG	YRG
T-7	50	30	11.97	132 / 13.8	YG	YRG
T-8	56.1	30	8.88	132 / 13.8	YG	YRG

GENROU – Generator STG1

Round Rotor Generator Model (Quadratic Saturation)

Generating capacity 43.0 MVA

CONs	#	Value	Description
J		8.0	T'_{do} (>0) (Seconds)
J + 1		0.04	T''_{do} (>0) (Seconds)
J + 2		1.0	T'_{qo} (>0) (Seconds)
J + 3		0.04	T''_{qo} (>0) (Seconds)
J + 4		2.02	Inertia H
J + 5		0.0	Speed Damping D
J + 6		1.74	X_d
J + 7		1.6	X_q
J + 8		0.25	X'_d
J + 9		0.8	X'_q
J + 10		0.22	$X''_d = X''_q$
J + 11		0.12	X_l
J + 12		0.095	S(1.0)
J + 13		0.362	S(1.2)

GENROU - Generator STG2
Round Rotor Generator Model (Quadratic Saturation)

Generating capacity 18.3 MVA

CONs	#	Value	Description
J		7.7	T'_{do} (>0) (Seconds)
J + 1		0.069	T''_{do} (>0) (Seconds)
J + 2		0.21	T'_{qo} (>0) (Seconds)
J + 3		0.207	T''_{qo} (>0) (Seconds)
J + 4		4.03	Inertia H
J + 5		0.0	Speed Damping D
J + 6		1.85	X_d
J + 7		1.09	X_q
J + 8		0.23	X'_d
J + 9		05	X'_q
J + 10		0.185	$X''_d = X''_q$
J + 11		0.12	X_l
J + 12		0.16	S(1.0)
J + 13		0.77	S(1.2)

Exciter Model

ESST4B – Generator STG1

IEEE Type ST4B Potential or Compounded Source-Controlled Rectifier Exciter

CONs	#	Value	Description
J		0.005	T_R (sec)
J + 1		40.6	K_{PR}
J + 2		10.1	K_{IR}
J + 3		99.	V_{RMAX}
J + 4		-99.	V_{RMIN}
J + 5		0.025	T_A (sec)
J + 6		1.0	K_{PM}
J + 7		0.0	K_{IM}
J + 8		5.0	V_{MMAX}
J + 9		-4.15	V_{MMIN}
J + 10		0.0	K_G
J + 11		1.0	K_P
J + 12		0.0	K_I
J + 13		1.15	V_{BMAX}
J + 14		0.05	K_C
J + 15		0.0	X_L
J + 16		0	THETAP

Exciter Model

REXSYS – Generator STG2

General purpose rotating excitation system model

CONs	#	Value	Description
J		0.01	Tr (sec)
J + 1		540.	Kvp
J + 2		0.	Kvi
J + 3		1.0	Vimax
J + 4		0.	Ta (sec)
J + 5		1.2	Tb1 (sec)
J + 6		0.3	Tc1 (sec)
J + 7		0.02	Tb2 (sec)
J + 8		0.38	Tc2 (sec)
J + 9		99.	VRmax
J + 10		-99.	VRmin
J + 11		0.	Kf
J + 12		1.	Tf (sec)
J + 13		0.1	Tf1 (sec)
J + 14		0.1	Tf2 (sec)
J + 15		0.	Fbf
J + 16		2.6	Kip
J + 17		0.	Kii
J + 18		0.01	Tp (sec)
J + 19		22.	VFmax
J + 20		-17.	VFmin
J + 21		1.	Kh
J + 22		1.	Ke
J + 23		0.6	Te (sec)
J + 24		0.6	Kc
J + 25		1.8	Kd
J + 26		6.45	E1
J + 27		0.035	SE(E1)
J + 28		8.6	E2
J + 29		0.15	SE(E2)
J = 30		0.0	F1imf

