Generation Interconnection

Feasibility Study Report

for

Queue Project AF2-077

WHITE MARSH 34.5 KV

12 MW Capacity / 20 MW Energy

July 2020

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1 Introduction

This Feasibility Study has been prepared in accordance with the PJM Open Access Transmission Tariff, 36.2, as well as the Feasibility Study Agreement between the Interconnection Customer (IC), and PJM Interconnection, LLC (PJM), Transmission Provider (TP). The Interconnected Transmission Owner (ITO) is Dominion.

2 Preface

The intent of the feasibility study is to determine a plan, with ballpark cost and construction time estimates, to connect the subject generation to the PJM network at a location specified by the Interconnection Customer. The Interconnection Customer may request the interconnection of generation as a capacity resource or as an energy-only resource. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: (1) Direct Connections, which are new facilities and/or facilities upgrades needed to connect the generator to the PJM network, and (2) Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system.

In some instances a generator interconnection may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection, may also contribute to the need for the same network reinforcement. Cost allocation rules for network upgrades can be found in PJM Manual 14A, Attachment B. The possibility of sharing the reinforcement costs with other projects may be identified in the feasibility study, but the actual allocation will be deferred until the impact study is performed.

The Interconnection Customer seeking to interconnect a wind or solar generation facility shall maintain meteorological data facilities as well as provide that meteorological data which is required per Schedule H to the Interconnection Service Agreement and Section 8 of Manual 14D.

The Feasibility Study estimates do not include the feasibility, cost, or time required to obtain property rights and permits for construction of the required facilities. The project developer is responsible for the right of way, real estate, and construction permit issues. For properties currently owned by Transmission Owners, the costs may be included in the study.

3 General

The Interconnection Customer (IC), has proposed a Solar generating facility located in Gloucester County, Virginia. The installed facilities will have a total capability of 20 MW with 12 MW of this output being recognized by PJM as Capacity. The proposed in-service date for this project is November 01, 2021. This study does not imply a TO commitment to this in-service date.

Queue Number	AF2-077
Project Name	WHITE MARSH 34.5 KV
State	Virginia
County	Gloucester
Transmission Owner	Dominion
MFO	20
MWE	20
MWC	12
Fuel	Solar
Basecase Study Year	2023

Any new service customers who can feasibly be commercially operable prior to June 1st of the basecase study year are required to request interim deliverability analysis.

4 Point of Interconnection

AF2-077 will interconnect with the Dominion distribution system. The POI is a direct connection to an existing White Marsh 34.5 kV substation in the Dominion area. This is the primary Point of Interconnection (POI) chosen by the IC with the ITO's transmission system. The IC is responsible for securing right-of-way, permits and constructing the proposed attachment line from the solar facility site to the proposed new substation. Attachment 1 shows a one-line diagram of the proposed interconnection facilities. The IC may not install any facilities on Dominion's right-of-way without first obtaining the necessary approval from Dominion Energy.

There is no secondary point of interconnection specified for AF2-077.

5 Cost Summary

The AF2-077 project will be responsible for the following costs:

Description	Total Cost
Total Physical Interconnection Costs	$ To be provided in the two-party IA with ITO
Total System Network Upgrade Costs	$ 840,000
Total Costs	$ 840,000

This cost excludes a Federal Income Tax Gross Up charges. This tax may or may not be charged based on whether this project meets the eligibility requirements of IRS Notice 88-129. If at a future date it is determined that the Federal Income Tax Gross charge is required, the Transmission Owner shall be reimbursed by the Interconnection Customer for such taxes.

Cost allocations for any System Upgrades will be provided in the System Impact Study Report.

6 Transmission Owner Scope of Work

Dominion assessed the impact of the proposed Queue Project AF2-077 was evaluated as a 12 MW Capacity (20.0 MW Energy) injection at the AF2-077 34.5 kV substation in the Dominion Distribution System, for compliance with NERC Reliability Criteria on Dominion Transmission System. The system was assessed using the summer 2023 AF2 case provided to Dominion by PJM. When performing a generation analysis, Dominion's main analysis will be load flow study results under single contingency (both normal and stressed system conditions). Dominion Criteria considers a transmission facility overloaded if it exceeds 94% of its emergency rating under normal and stressed system conditions. A full listing of Dominion's Planning Criteria and interconnection requirements can be found in the Company's Facility Connection Requirements which are publicly available at: http://www.dominionenergy.com.

The results of these studies evaluate the system under a limited set of operating conditions and do not guarantee the full delivery of the capacity and associated energy of this proposed generation facility under all operating conditions. NERC Planning and Operating Reliability Criteria allow for the re-dispatch of generating units to resolve projected and actual deficiencies in real time and planning studies. Specifically, in Planning Studies, NERC Planning Event 3 and 6 Contingency Conditions (Loss of generator, transmission circuit, transformer, shunt device, or Single Ple of a DC line followed by the loss of a generator, transmission circuit, transformer, shunt device or single pole of a DC line) allow for re-dispatch of generating units to resolve potential reliability deficiencies. For Dominion Planning Criteria the re-dispatch of generating units for these contingency conditions is allowed as long as the projected loading does not exceed 100% of a facility Load Dump Rating.

The required Attachment Facilities, Direct Connection and Non-Direct Connection work for the interconnection of the AF2-077 generation project to the Dominion Transmission System is detailed in the following sections. The associated one-line with the generation project attachment facilities and primary direct and non-direct connection are shown in Attachment 1.

Note that the ITO findings were made from a conceptual review of this project. A more detailed review of the connection facilities and their cost will be identified in a future study phases. Further note that the cost estimate data contained in this document should be considered high level estimates since it was produced without a detailed engineering review. The applicant will be responsible for the actual cost of construction.

ITO herein reserves the right to return to any issues in this document and, upon appropriate justification, request additional monies to complete any reinforcements to the transmission systems.

7 Schedule

The schedule for the required Network Impact Reinforcements will be more clearly identified in future study phases. The estimate elapsed time to complete each of the required reinforcements is identified in the "System Reinforcements" section of the report.

8 Transmission Owner Analysis

8.1 Power Flow Analysis

PJM performed a power flow analysis of the transmission system using a 2023 summer peak load flow model and the results were verified by Dominion. Additionally, Dominion performed an analysis of its transmission system and no further deficiencies were identified.

9 Interconnection Customer Requirements

9.1 System Protection

The IC must design its Customer Facilities in accordance with all applicable standards, including the standards in Dominion's "Dominion Energy Electric Transmission Generator Interconnection Requirements" documented in Dominion's Facility Interconnection Requirements "Exhibit C" located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access. Preliminary Protection requirements will be provided as part of the Facilities Study. Detailed Protection Requirements will be provided once the project enters the construction phase.

9.2 Compliance Issues and Interconnection Customer Requirements

The proposed Customer Facilities must be designed in accordance with Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access. In particular, the IC is responsible for the following:

1. The purchase and installation of a fully rated protection device (circuit breaker, circuit switcher, fuse) to protect the IC's GSU transformer(s).

2. The purchase and installation of the minimum required Dominion generation interconnection relaying and control facilities as described in the System Protection noted above. This includes over/under voltage protection, over/under frequency protection, and zero sequence voltage protection relays.

3. The purchase and installation of supervisory control and data acquisition ("SCADA") equipment to provide information in a compatible format to the Dominion Transmission System Control Center.

4. Compliance with the Dominion and PJM generator power factor and voltage control requirements.

The GSU(s) associated with the IC queue request shall meet the grounding requirements as noted in Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access.

The IC will also be required to meet all PJM, SERC, and NERC reliability criteria and operating procedures for standards compliance. For example, the IC will need to properly locate and report the over and under voltage and over and under frequency system protection elements for its units as well as the submission of the generator model and protection data required to satisfy the PJM and SERC audits. Failure to comply with these requirements may result in a disconnection of service if the violation is found to compromise the reliability of the Dominion system.

9.3 Power Factor Requirements

The IC shall design its non-synchronous Customer Facility with the ability to maintain a power factor of at least 0.95 leading (absorbing VARs) to 0.95 lagging (supplying VARs) measured at the high-side of the facility substation transformer(s) connected to the Dominion transmission system.

10 Revenue Metering and SCADA Requirements

10.1 PJM Requirements

The Interconnection Customer will be required to install equipment necessary to provide Revenue Metering (KWH, KVARH) and real time data (KW, KVAR) for IC's generating Resource. See PJM Manuals M-01 and M-14D, and PJM Tariff Section 8 of Attachment O.

10.2 Meteorological Data Reporting Requirements

The solar generation facility shall provide the Transmission Provider with site-specific meteorological data including:

- Back panel temperature (Fahrenheit)
- Irradiance (Watts/meter^2)
- Ambient air temperature (Fahrenheit) - (Accepted, not required)
- Wind speed (meters/second) – (Accepted, not required)
- Wind direction (decimal degrees from true north) – (Accepted, not required)

10.3 Interconnected Transmission Owner Requirements

See Section 3.4.6 "Metering and telecommunications" of Dominion's "Dominion's Facility Interconnection Requirements" document located at: https://www.dominionenergy.com/company/moving-energy/electric-transmission-access.

11 Summer Peak - Load Flow Analysis

The Queue Project AF2-077 was evaluated as a 20.0 MW (Capacity 12.0 MW) injection at the White Marsh 115 kV substation in the Dominion area. Project AF2-077 was evaluated for compliance with applicable reliability planning criteria (PJM, NERC, NERC Regional Reliability Councils, and Transmission Owners). Project AF2-077 was studied with a commercial probability of 53.0 %. Potential network impacts were as follows:

11.1 Generation Deliverability

(Single or N-1 contingencies for the Capacity portion only of the interconnection)

None

11.2 Multiple Facility Contingency

(Double Circuit Tower Line, Fault with a Stuck Breaker, and Bus Fault contingencies for the full energy output)

None

11.3 Contribution to Previously Identified Overloads

(This project contributes to the following contingency overloads, i.e. "Network Impacts", identified for earlier generation or transmission interconnection projects in the PJM Queue)

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
9715370 7	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	DVP_P2-2: LANEXAB1	bus	208.0	107.45	113.63	DC	12.85
9715390 7	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	DVP_P4-6: LANEXAT122	breaker	208.0	107.88	114.06	DC	12.85
9715390 8	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	DVP_P4-2: 201632	breaker	208.0	105.99	112.64	DC	13.82
9715498 4	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	DVP_P7-1: LN 85-2016-B	tower	208.0	120.95	128.52	DC	15.75

11.4 Potential Congestion due to Local Energy Deliverability

PJM also studied the delivery of the energy portion of this interconnection request. Any problems identified below are likely to result in operational restrictions to the project under study. The developer can proceed with network upgrades to eliminate the operational restriction at their discretion by submitting a Merchant Transmission Interconnection request.

Note: Only the most severely overloaded conditions are listed below. There is no guarantee of full delivery of energy for this project by fixing only the conditions listed in this section. With a Transmission Interconnection Request, a subsequent analysis will be performed which shall study all overload conditions associated with the overloaded element(s) identified.

ID	FROM BUS#	FROM BUS	kV	FROM BUS AREA	TO BUS#	TO BUS	kV	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
97154391	313828	3WHITEMARSH	115.0	DVP	314174	3HARMONY	115.0	DVP	1	DVP_P1-2: LN 89-B	operation	169.199996948	88.48	100.3	DC	20.0
97154233	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	DVP_P1-2: LN 2016	operation	169.199996948	128.54	136.65	DC	13.72
97154238	945360	AF1-201 TAP	115.0	DVP	314177	3HAYES89	115.0	DVP	1	Base Case	operation	169.199996948	108.54	115.81	DC	12.29

11.5 System Reinforcements - Summer Peak Load Flow - Primary POI

ID	Idx	Facility	Upgrade Description	Cost
97153907,97154984,97153908,97153707	1	AF1-201 TAP 115.0 kV - 3HAYES89 115.0 kV Ckt 1	DVP dom-145 (1197) : Reconductor 1.4 miles of 115 kV Line 89 from Hayes to AF1-201 Tap with 636 ACSR Project Type : FAC Cost : $840,000 Time Estimate : 30-36 Months	$840,000
			TOTAL COST	$840,000

11.6 Flow Gate Details

The following indices contain additional information about each facility presented in the body of the report. For each index, a description of the flowgate and its contingency was included for convenience. The intent of the indices is to provide more details on which projects/generators have contributions to the flowgate in question. All New Service Queue Requests, through the end of the Queue under study, that are contributors to a flowgate will be listed in the indices. Please note that there may be contributors that are subsequently queued after the queue under study that are not listed in the indices. Although this information is not used "as is" for cost allocation purposes, it can be used to gage the impact of other projects/generators. It should be noted the project/generator MW contributions presented in the body of the report are Full MW Impact contributions which are also noted in the indices column named "Full MW Impact", whereas the loading percentages reported in the body of the report, take into consideration the PJM Generator Deliverability Test rules such as commercial probability of each project as well as the ramping impact of "Adder" contributions. The MW Impact found and used in the analysis is shown in the indices column named "Gendeliv MW Impact".

11.6.1 Index 1

ID	FROM BUS#	FROM BUS	FROM BUS AREA	TO BUS#	TO BUS	TO BUS AREA	CKT ID	CONT NAME	Type	Rating MVA	PRE PROJECT LOADING %	POST PROJECT LOADING %	AC|DC	MW IMPACT
97154984	945360	AF1-201 TAP	DVP	314177	3HAYES89	DVP	1	DVP_P7-1: LN 85-2016-B	tower	208.0	120.95	128.52	DC	15.75

Bus #	Bus	Gendeliv MW Impact	Type	Full MW Impact
315034	1NORNECKC1	0.6574	50/50	0.6574
315035	1NORNECKC2	0.6336	50/50	0.6336
926472	AC1-118 E	0.4224	Adder	0.5
933271	AC2-138 C	0.7346	50/50	0.7346
933272	AC2-138 E	0.9183	50/50	0.9183
934141	AD1-041 C	17.3841	50/50	17.3841
934142	AD1-041 E	11.5894	50/50	11.5894
936241	AD2-030 C	1.3094	50/50	1.3094
936242	AD2-030 E	3.8824	50/50	3.8824
936341	AD2-044 C	0.2296	50/50	0.2296
936342	AD2-044 E	0.2602	50/50	0.2602
936581	AD2-073 C	0.9046	Adder	1.06
936582	AD2-073 E	0.4482	Adder	0.53
936591	AD2-074 C	10.3334	50/50	10.3334
936592	AD2-074 E	16.8598	50/50	16.8598
939241	AE1-155 C	24.9623	50/50	24.9623
939242	AE1-155 E	16.6415	50/50	16.6415
939611	AE1-191 C	34.7682	50/50	34.7682
939612	AE1-191 E	23.1788	50/50	23.1788
943741	AF1-042 C	5.4070	50/50	5.4070
943742	AF1-042 E	8.8220	50/50	8.8220
945361	AF1-201 C O1	76.6287	50/50	76.6287
945362	AF1-201 E O1	51.0858	50/50	51.0858
945831	AF1-248	0.3214	50/50	0.3214
957601	AF2-054 C	6.9189	50/50	6.9189
957602	AF2-054 E	4.6126	50/50	4.6126
957831	AF2-077 C	9.4474	50/50	9.4474
957832	AF2-077 E	6.2982	50/50	6.2982
958261	AF2-120 C	10.3870	50/50	10.3870
958262	AF2-120 E	6.9247	50/50	6.9247
NEWTON	NEWTON	0.0698	Confirmed LTF	0.0698
FARMERCITY	FARMERCITY	0.0041	Confirmed LTF	0.0041
G-007A	G-007A	0.2062	Confirmed LTF	0.2062
VFT	VFT	0.5547	Confirmed LTF	0.5547
CALDERWOOD	CALDERWOOD	0.0626	Confirmed LTF	0.0626
PRAIRIE	PRAIRIE	0.1963	Confirmed LTF	0.1963
CHEOAH	CHEOAH	0.0646	Confirmed LTF	0.0646
EDWARDS	EDWARDS	0.0207	Confirmed LTF	0.0207
TILTON	TILTON	0.0365	Confirmed LTF	0.0365
GIBSON	GIBSON	0.0333	Confirmed LTF	0.0333
BLUEG	BLUEG	0.1042	Confirmed LTF	0.1042

Bus #	Bus	Gendeliv MW Impact	Type	Full MW Impact
TRIMBLE	TRIMBLE	0.0328	Confirmed LTF	0.0328
CATAWBA	CATAWBA	0.0693	Confirmed LTF	0.0693

11.7 Queue Dependencies

The Queue Projects below are listed in one or more indices for the overloads identified in your report. These projects contribute to the loading of the overloaded facilities identified in your report. The percent overload of a facility and cost allocation you may have towards a particular reinforcement could vary depending on the action of these earlier projects. The status of each project at the time of the analysis is presented in the table. This list may change as earlier projects withdraw or modify their requests.

Queue Number	Project Name	Status
AC1-118	Westmoreland 34.5kV	In Service
AC2-138	Northern Neck 34.5kV	Under Construction
AD1-041	Harmony Village-Shackleford 115 kV	Active
AD2-030	Wan 34.5 kV	In Service
AD2-044	Northern Neck 34.5 kV	Under Construction
AD2-073	Sanders DP 230 kV	Active
AD2-074	Garner DP-Lancaster 115 kV	Active
AE1-155	Garner-Northern Neck 115 kV	Active
AE1-191	Harmony Village-Shackleford 115 kV	Active
AF1-042	Garner DP-Lancaster 115 kV	Active
AF1-201	Hayes-Whitemarsh 115 kV	Active
AF1-248	Northern Neck 34.5 kV	Engineering and Procurement
AF2-054	Wan 34.5 kV	Active
AF2-077	White Marsh 34.5 kV	Active
AF2-120	Garner-Northern Neck 115 kV	Active

11.8 Contingency Descriptions

Contingency Name	Contingency Definition
DVP_P4-6: LANEXA T122	CONTINGENCY 'DVP_P4-6: LANEXA T122' /* LANEXA 115 KV OPEN BUS 314387 /* 3LANEXA 115.00 KV END
DVP_P1-2: LN 2016	CONTINGENCY 'DVP_P1-2: LN 2016' OPEN BRANCH FROM BUS 314174 TO BUS 314176 CKT 1 /* 3HARMONY 115.00 - 6HARMONY 230.00 OPEN BRANCH FROM BUS 314176 TO BUS 314189 CKT 1 /* 6HARMONY 230.00 - 6PAPERMILL 230.00 OPEN BRANCH FROM BUS 314189 TO BUS 314375 CKT 1 /* 6PAPERMILL 230.00 - 6CORRCTN 230.00 OPEN BRANCH FROM BUS 314375 TO BUS 314388 CKT 1 /* 6CORRCTN 230.00 - 6LANEXA 230.00 OPEN BUS 313846 /* ISLAND: 6HARMONY_1 230.00 OPEN BUS 314176 /* ISLAND: 6HARMONY 230.00 OPEN BUS 314189 /* ISLAND: 6PAPERMILL 230.00 OPEN BUS 314375 /* ISLAND: 6CORRCTN 230.00 OPEN BUS 923842 /* ISLAND: AB2-024 E 230.00 END
DVP_P7-1: LN 85-2016-B	CONTINGENCY 'DVP_P7-1: LN 85-2016-B' OPEN BRANCH FROM BUS 934140 TO BUS 314184 CKT 1 /* AD1-041 TAP 115.00 - 3SHACKLE 115.00 OPEN BRANCH FROM BUS 314184 TO BUS 314188 CKT 1 /* 3SHACKLE 115.00 - 3WEST PT 115.00 OPEN BRANCH FROM BUS 314188 TO BUS 314387 CKT 1 /* 3WEST PT 115.00 - 3LANEXA 115.00 OPEN BUS 314184 /* ISLAND: 3SHACKLE 115.00 OPEN BUS 314188 /* ISLAND: 3WEST PT 115.00 OPEN BRANCH FROM BUS 314174 TO BUS 314176 CKT 1 /* 3HARMONY 115.00 - 6HARMONY 230.00 OPEN BRANCH FROM BUS 314176 TO BUS 314189 CKT 1 /* 6HARMONY 230.00 - 6PAPERMILL 230.00 OPEN BRANCH FROM BUS 314189 TO BUS 314375 CKT 1 /* 6PAPERMILL 230.00 - 6CORRCTN 230.00 OPEN BRANCH FROM BUS 314375 TO BUS 314388 CKT 1 /* 6CORRCTN 230.00 - 6LANEXA 230.00 OPEN BUS 313846 /* ISLAND: 6HARMONY_1 230.00 OPEN BUS 314176 /* ISLAND: 6HARMONY 230.00 OPEN BUS 314189 /* ISLAND: 6PAPERMILL 230.00 OPEN BUS 314375 /* ISLAND: 6CORRCTN 230.00 END

Contingency Name	Contingency Definition
DVP_P2-2: LANEXA B1	CONTINGENCY 'DVP_P2-2: LANEXA B1' /* LANEXA 115 KV OPEN BRANCH FROM BUS 314188 TO BUS 314387 CKT 1 /* 3WEST PT 115.00 - 3LANEXA 115.00 OPEN BRANCH FROM BUS 314243 TO BUS 314387 CKT 1 /* 3PROV 92 115.00 - 3LANEXA 115.00 OPEN BRANCH FROM BUS 314387 TO BUS 314388 CKT 2 /* 3LANEXA 115.00 - 6LANEXA 230.00 END
Base Case	
DVP_P1-2: LN 89-B	CONTINGENCY 'DVP_P1-2: LN 89-B' OPEN BRANCH FROM BUS 945360 TO BUS 314177 CKT 1 /* AF1-201 TAP 115.00 - 3HAYES89 115.00 END
DVP_P4-2: 201632	CONTINGENCY 'DVP_P4-2: 201632' /* LANEXA 230 KV OPEN BRANCH FROM BUS 314174 TO BUS 314176 CKT 1 /* 3HARMONY 115.00 - 6HARMONY 230.00 OPEN BRANCH FROM BUS 314176 TO BUS 314189 CKT 1 /* 6HARMONY 230.00 - 6PAPERMILL 230.00 OPEN BRANCH FROM BUS 314189 TO BUS 314375 CKT 1 /* 6PAPERMILL 230.00 - 6CORRCTN 230.00 OPEN BRANCH FROM BUS 314375 TO BUS 314388 CKT 1 /* 6CORRCTN 230.00 - 6LANEXA 230.00 OPEN BUS 313846 /* ISLAND: 6HARMONY_1 230.00 OPEN BUS 314176 /* ISLAND: 6HARMONY 230.00 OPEN BUS 314189 /* ISLAND: 6PAPERMILL 230.00 OPEN BUS 314375 /* ISLAND: 6CORRCTN 230.00 OPEN BUS 923842 /* ISLAND: AB2-024 E 230.00 OPEN BRANCH FROM BUS 314387 TO BUS 314388 CKT 2 /* 3LANEXA 115.00 - 6LANEXA 230.00 OPEN BUS 314440 /* 6LANEX_1 230.00 KV END

12 Short Circuit Analysis

Short circuit analysis will be provided in the System Impact Study report.

13 Affected Systems

13.1 TVA

TVA Impacts to be determined during later study phases (as applicable).

13.2 Duke Energy Progress

Duke Energy Progress Impacts to be determined during later study phases (as applicable).

14 Attachment 1: One Line Diagram