Generation Interconnection Facilities Study Report

For

PJM Generation Interconnection Request Queue Position Z1-109

VFT – Tosco 230 kV

January 2016

General

East Coast Power LLC, the Interconnection Customer (IC), has proposed a natural gas generating facility located in Linden, New Jersey. The installed facilities will have a total capability of 208 MW with 208 MW of this output being recognized by PJM as capacity. The proposed in-service date for this project is June 30, 2016. **This study does not imply a PSE&G commitment to this in-service date.**

Point of Interconnection

Z1-109 will interconnect with the PSE&G transmission system via a new three breaker ring bus that connects to the S-2271 230 kV line between the Tosco and VFT substations.

Cost Summary

The Z1-109 project will be responsible for the following costs:

Description	Total Cost
Attachment Facilities	$ 829,393
Direct Connection Network Upgrades	$ 43,046,607
Non Direct Connection Network Upgrades	$ 0
Allocation for New System Upgrades	$ 0
Contribution for Previously Identified Upgrades	$ 0
Total Costs	**$ 43,876,000**

Note: This table assumes construction of the facility at the “Track C” location.

Executive Summary

East Coast Power, LLC (ECP), the Interconnection Customer (IC), has proposed a 208 MWC (208 MW MFO) natural gas fueled generating facility in the city of Linden, Union County, New Jersey. The IC has two proposed locations for the ECP generating facility: “L7” and “Track C”. The point of interconnect (POI) for this project is a termination structure in the new Public Service Electric and Gas Company (PSE&G), three-breaker, ring bus, gas-insulated switchgear substation (PSE&G ECP Substation) that breaks the existing S-2271 230kV line between the existing Tosco and VFT Substations. The PSE&G ECP Substation will be located adjacent to the proposed ECP generation facility switchyard (ECP Switchyard) and connected by means of a new underground, XLPE transmission line. The PSE&G ECP Substation is connected to the S-2271 line by means of a new double-circuit, aerial 230kV transmission line between the breakpoint in the existing S-2271 line and the new PSE&G ECP Substation.

The proposed in-service date for the project is June 30, 2016.

From PSE&G’s perspective, subject to the assumptions tabulated throughout this study, the requested in-service date of June 30, 2016 cannot be met, with the PSE&G portion of the project expected to be complete by December 2018. In order to maintain this schedule, an executed Construction Service Agreement (CSA) is required no later than January 30, 2016. Any delay to the execution of this document will result in a delay to the projected in-service date.

A. Transmission Owner Facilities Study Summary

1. Description of Project

East Coast Power, LLC (ECP), the Interconnection Customer (IC), has proposed a 208 MWC (208 MW MFO) natural gas fueled generating facility in the city of Linden, Union County, New Jersey. The IC has two proposed locations for the ECP generating facility: “L7” and “Track C”. The point of interconnect (POI) for this project is a termination structure in the new Public Service Electric and Gas Company (PSE&G), three-breaker, ring bus, gas-insulated switchgear substation (PSE&G ECP Substation) that breaks the existing S-2271 230kV line between the existing Tosco and VFT Substations. The PSE&G ECP Substation will be located adjacent to the proposed ECP generation facility switchyard (ECP Switchyard) and connected by means of a new underground, XLPE transmission line. The PSE&G ECP Substation is connected to the S-2271 line by means of a new double-circuit, aerial 230kV transmission line between the breakpoint in the existing S-2271 line and the new PSE&G ECP Substation.

The proposed in-service date for the project is June 30, 2016.

The two proposed facility locations, their corresponding substation locations, the Tosco and VFT Substations, the existing S-2271 line, and the proposed transmission lines are shown in Attachment 1.

2. Amendments to the System Impact Study data or System Impact Study Results

The project costs and construction schedule have been refined in this report for increased accuracy and thereby differ from that which was presented in the Feasibility and System Impact Study reports. All estimates have been created based on meeting the earliest in-service date possible at the request of the IC. From PSE&G’s perspective, subject to the assumptions tabulated throughout this study, the requested in-service date of June 30, 2016 cannot be met. The PSE&G portion of the project is expected to be complete by December 2018. In order to maintain this schedule, an executed Construction Service Agreement (CSA) is required no later than January 30, 2016. Any delay to the execution of this document will result in a delay to the projected in-service date.

3. Interconnection Customer’s Submitted Milestone Schedule

The IC will construct a new 230kV underground transmission line from the ECP Switchyard to the POI, which is located on the steel termination structure at the PSE&G ECP Substation. The schedule for building the new 230kV underground transmission line was not available, but is assumed to be consistent with the in-service date for the IC’s new generating facility.

4. Scope of Customer’s Work

The IC will construct the ECP Switchyard, a new 230kV switchyard adjacent to its new generating facility to connect with the Generator Step-Up (GSU) transformer. The ECP Switchyard will include a 230kV switch, and cable termination structure.

The IC will also construct a new 230kV underground transmission line from the ECP Switchyard to the POI steel termination structure at the PSE&G ECP Substation, as shown on the one-line diagram – Attachment 2 – and the interconnect general arrangements – Attachments 3 and 4. The IC will be responsible for acquiring all of the new right of way, easements and permits needed for this new underground attachment line and will be responsible for constructing, owning, operating and maintaining this attachment line.

The IC will coordinate its commissioning and testing with the work to be performed by PSE&G in the new PSE&G ECP Substation and at the Tosco 230kV and VFT 230kV Switching Station control houses.

5. Description of Facilities Included in the Facilities Study

This report describes the electrical facilities and system upgrades necessary to support the IC's project. PSE&G will install the PSE&G ECP Substation to accommodate the connection of the ECP generation facility to the existing S-2271 230kV transmission line between Tosco and VFT substations.

The PSE&G ECP Substation will be composed of a 230kV, three-breaker, ring-bus, gas-insulated switchgear and will include provisions for a fourth breaker to accommodate future increase in generation.

PSE&G will allocate one position in the PSE&G ECP Substation for the 230kV underground connection to the ECP Switchyard. The Attachment Facilities include the underground cable terminations, the terminators to the IC's underground line, the steel termination structure and associated foundation inside the PSE&G ECP Substation property, aerial conductor, dead-end insulators, GIS bushings, line differential relays, metering, connectors and other necessary line hardware and will be furnished, installed and maintained by PSE&G.

PSE&G will allocate one position in the PSE&G ECP Substation for the 230kV aerial connection to the existing Tosco Substation and one position for the 230kV aerial connection to the existing VFT Substation. The connections to Tosco and VFT will be constructed as double-circuit aerial construction up to the location of the break into the S-2271 line. The conductor, structures, foundations, terminations, insulators, GIS bushings, connectors and other necessary line hardware will be furnished, installed and maintained by PSE&G. PSE&G requires an air insulated line disconnect between the GIS bushings and the underground cable terminations. This line disconnect is not included in the scope of this Facility Study due to the space constraints of the available property.

In order to match the protection provided by PSE&G at the POI, the IC must provide the same line protection and relay communication equipment at the ECP Switchyard

The expenses for construction of the PSE&G ECP Substation, the construction of the new aerial transmission lines and the break-in to the existing S-2271 transmission line are included in the cost of Direct Connection Network Upgrades summarized in section 6 below.

Major primary electrical equipment includes:

Qty	Voltage	Amperage	Device
3	230kV	4000A	SF_6 Circuit Breaker
2	230kV	4000A	Line Disconnect
1			Substation Building and Systems
1			Double-circuit A-Frame Structure
3 or 4			Steel Monopole Structure

6. Total Costs of Transmission Owner Facilities included in Facilities Study

The costs estimated below are in 2015 dollars and do not include a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether or not the facilities meet the eligibility requirements of IRS Notice 88-129:

PSE&G - Z1-109	Base Cost	
Attachment Facilities	$	829,393
Direct Connection Network Upgrades	$	43,046,607
Non Direct Connection Network Upgrades	$	-
Total Costs	**$**	**43,876,000**

Note: This table assumes construction of the facility at the "Track C" location.

7. Summary of Milestone Schedules for Completion of Work Included in Facilities Study:

A proposed thirty-five (35) month direct connection construction schedule is estimated to complete construction and the associated activities listed below from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" section of this document are resolved, relevant PJM RTEP baseline projects will be completed and outages will occur as planned. A more detailed construction schedule with milestones will be developed for the Interconnection Construction Service Agreement. Construction cannot begin until after all applicable permits and/or easements have been obtained.

The following schedule is contingent upon receipt of an executed CSA by January 30, 2016. Any delay to the execution of this document will result in a delay to the projected in-service date:

PSE&G - Z1-109 Schedule	Start	Finish
Executed CSA		Jan-16
Engineering and Design	Feb-16	Jan-18
Material Procurement	May-16	Jan-18
Construction	Jul-17	Oct-18
Testing and Commissioning	Sep-18	Dec-18
In-Service		Dec-18

B. Transmission Owner Facilities Study Results

The facilities identified to be installed, replaced, and/or upgraded by PSE&G to accommodate the proposed project are described in this section. During detailed design and analysis, other components may be identified for installation or replacement due to this project.

1. Transmission Lines – New

PSE&G will install a new double-circuit aerial line between the break in the existing S-2271 230kV transmission line and the new PSE&G ECP Substation. The break in to the existing transmission line will be supported with a new double-corner pole placed in the existing transmission line right of way. The new double-circuit aerial line will be terminated at a new two- circuit A-frame structure at the PSE&G ECP Substation. The balance of the line – 1230 feet for the "L7" site or 1720 feet for the "Track C" site – will be constructed with steel monopoles, 1590 KCMIL ACSS conductor, an optical ground wire (OPGW).

Since the IC has two potential sites for the ECP generation facility, PSE&G has studied two locations for the PSE&G ECP Substation and subsequently two transmission line routes. The two transmission routes are described in Attachment 1. The table below indicates the installation cost for each of the proposed transmission lines. The costs estimated below are in 2015 dollars and do not include a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether or not the facilities meet the eligibility requirements of IRS Notice 88-129:

PSE&G – Z1-109 Transmission Lines - New	Base Cost
S-2271 Tosco-VFT to "L7"	$ 7,114,900
S-2271 Tosco-VFT to "Track C"	$ 9,152,000

A proposed total thirty-three (33) month construction schedule based on a January 2016 start is estimated to complete all of the PSE&G construction and associated activities listed below from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" section of this document are resolved, and outages will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

PSE&G – Z1-109 Transmission Lines - New				
Activity	Duration (Months)	Start	Finish	Project Months
Executed CSA			16-Jan	
Siting and Permitting	24	16-Feb	18-Jan	1 through 24
Preliminary Engineering	3	16-Feb	16-Apr	1 through 3
Detailed Design	9	16-May	17-Jan	4 through 12
Material Procurement	12	17-Feb	18-Jan	13 through 24
Construction	4	18-May	18-Aug	28 through 31
Testing and Commissioning	1	18-Sep	18-Sep	32 through 33
In-Service			18-Oct	33

2. Transmission Line – Upgrades

None.

3. New Substation/Switchyard Facilities

- PSE&G ECP Substation – three-breaker, ring-bus, gas-insulated switchgear substation.

PSE&G will install one (1) new three-breaker, ring-bus substation utilizing gas-insulated (GIS) equipment located adjacent to the IC's proposed generating facility. The new substation will be equipped with three (3) 230kV GIS breakers and provisions for a fourth breaker for future expansion. The substation equipment will be housed in a new concrete equipment building with a separated control room. Two (2) station service transformers and one (1) stand-by generator will be installed at the substation to provide service to the station and equipment. The building and all equipment will be elevated three (3) feet above existing grade to mitigate susceptibility to flooding. Attachment 5 shows the PSE&G ECP Substation general arrangement. As stated previously, the general arrangement does not include an air insulated line disconnect between the GIS bushings and underground cable terminations.

The table below indicates the installation cost for the proposed substation. The cost to construct the substation is not expected to change significantly between the two proposed locations. The costs estimated below are in 2015 dollars and do not include a CIAC (Contribution in Aid of Construction) Federal Income Tax Gross Up charge. This tax may or may not be charged based on whether or not the facilities meet the eligibility requirements of IRS Notice 88-129:

PSE&G – Z1-109 New Substation / Switchyard Facilities	Upgrade Cost
PSE&G ECP Substation	$ 33,894,607

A proposed total thirty-five (35) month construction schedule based on a January 2016 start is estimated to complete all of the PSE&G construction and associated activities listed below from the date of a fully executed Interconnection Construction Service Agreement and Construction Kick-Off Meeting. This schedule assumes that all issues covered by the "Environmental, Real Estate and Permitting Issues" section of this document are resolved, and outages will occur as planned. Construction cannot begin until after all applicable permits and/or easements have been obtained.

PSE&G – Z1-109 New Substation / Switchyard Facilities				
Activity	Duration (Months)	Start	Finish	Project Months
Executed CSA			Jan-16	
Siting and Permitting	24	Feb-16	Jan-18	1 through 24
Preliminary Engineering	6	Feb-16	Jul-16	1 through 6
Detailed Design	9	Aug-16	Apr-17	7 through 15
Material Procurement	14	Dec-16	Jan-18	11 through 24
Construction	10	Jan-18	Oct-18	24 through 33
Testing and Commissioning	2	Nov-18	Dec-18	34 through 35
In-Service			Dec-18	35

4. Upgrades to Substation / Switchyard Facilities

No upgrades to substations or switchyards are required.

5. Metering & Communications

The IC will be required to comply with all PSE&G Revenue Metering Requirements for Generation Interconnection Customers. The Revenue Metering Requirements may be found within the "Information and Requirements for Electric Service" document located at the following links:

http://www.pseg.com/business/builders/new_service/before/ http://www.pjm.com/planning/design-engineering/to-tech-standards.aspx

These requirements are in addition to any metering required by PJM.

Metering instrument transformers will be located on PSE&G's side of the POI, at the line terminal inside the new PSE&G ECP Substation described in Section 3.

The IC will be responsible for designing, furnishing and installing a Supervisory Control and Data Acquisition Remote Terminal Unit (SCADA RTU) in its generation substation, and for obtaining the telecommunication circuits from the RTU to the PSE&G Electric System Operations Center (ESOC).

Fiber Optic Communication Channels

For the purpose of relay communications, the IC will design, provide, install, own and maintain two (2) independent sets of fiber optic communications channels between the ECP Switchyard and the PSE&G ECP Substation.

6. Environmental, Real Estate and Permitting Issues

It is assumed that the IC and PSE&G will obtain all necessary permits in a timely fashion so as to allow construction to proceed according to the schedule outlined in this document. Any additional time required for this process will extend the project schedule.

The following are possible environmental, real estate and permitting issues:

- Environmental permitting, Real Estate acquisition NJBPU notification durations vary, some up to twelve (12) months, with a potential for significantly longer durations.
- Work at the new substation described in Section 3 may involve environmental surveys, permits, approvals and plans with federal, state, and/or local environmental agencies and/or county conservation districts.

7. Summary of Results of Study

The estimated costs and schedules for the work described above are tabulated in the appropriate sections. All estimates for cost and schedule are subject to the following assumptions.

General Assumptions:

1. Required transmission line outages can be scheduled as planned. Transmission line outages are:
    a. typically not taken from June to September,
    b. discouraged during extreme winter conditions, and
    c. in some cases, must be scheduled twelve (12) or more months in advance.
2. No delays due to equipment delivery, environmental, regulatory, permitting, real estate, extreme weather, or events generally understood to be classified as Force Majeure.
3. Sub-surface geotechnical work for the attachment facilities, PSE&G ECP Substation and new aerial transmission lines will be performed by the IC.
4. No significant rock or soil remediation issues encountered during construction, and soil conditions suitable for standard ground-grid and foundation installations.
5. For the new 230kV attachment line, the IC will be responsible for work including but not limited to the following:
    a. Preparing all necessary Erosion and Sediment Control plans and acquiring all NPDES and other permits as required.
    b. Building all necessary access roads for project sites.
    c. Conducting all necessary wetlands and waterways studies, historical and archaeological studies and obtaining the associated permits.
6. For the new transmission line and new PSE&G ECP substation, construction will be scheduled to avoid winter (December-March) whenever appropriate.
7. Risk and Contingency is based on PJM guidelines of 30%. PSE&G would typically apply 50% Risk and Contingency on study level estimates.

Engineering Assumptions:

1. Subsurface investigation reports were not available at the time of this study. Detailed foundation design has not been performed for the new transmission line or the new substation.
2. Utility power for station service is readily available to the new PSE&G ECP substation facility from two separate local utility sources.
3. Communication service is readily available to the new PSE&G ECP substation facility.

Siting Assumptions:

1. No appeals for local zoning issues filed with the New Jersey Board of Public Utilities (NJBPU) for any aspect of the project. If this type of appeal is required, additional project costs and extension of project schedule with the potential for rejection or significant modifications.

2. Subject to further study, there are no significant social or ecological impacts associated with the project that cannot be mitigated through permitting processes and different construction techniques.
3. No wetlands are included in the project right-of-way or limits of construction for the new transmission line, the new substation or the attachment facilities.
4. The proposed new transmission line and new substation are not located within a FEMA flood zone.
5. Subject to further study, no significant social or ecological impacts associated with the transmission line upgrade that cannot be mitigated through permitting processes and different construction techniques.
6. Estimate assumes no major difficulties in access to the existing and new transmission structures and the new PSE&G ECP substation. It is assumed that some access roads will be required.

Right-of-Way Assumptions:

1. Schedules assume no delays in acquisition of Rights-of-Way or subdivisions. Delay in acquiring property will delay the in-service date of the facility.
2. The proposed transmission line will be sited on a new utility Right-of-Way.
3. The proposed PSE&G ECP substation will be sited on a new PSE&G subdivision. Land acquisition costs are not included in this study.

Environmental Assumptions:

1. This estimate includes delineation/survey of all regulated areas, completion of a Soil Erosion and Sedimentation Control Plan, obtaining a Construction Stormwater Permit and the utilization of PSE&G's New Jersey Department of Environmental Protection (NJDEP) multi permit for maintenance. This maintenance permit cannot be utilized if any new poles are installed or if widening of the right of way is required. Such changes will result in increased environmental costs.
2. Permitting for temporary and permanent erosion and sedimentation controls are included for the new transmission line, and new substation.
3. Construction and maintenance of temporary erosion and sedimentation controls are included in the scope of work for the new transmission line and new substation.
4. Work for the attachment facilities, PSE&G ECP Substation and new aerial transmission lines are located on a known contaminated site in the state of New Jersey and the costs for compliance during construction are not included in this estimate

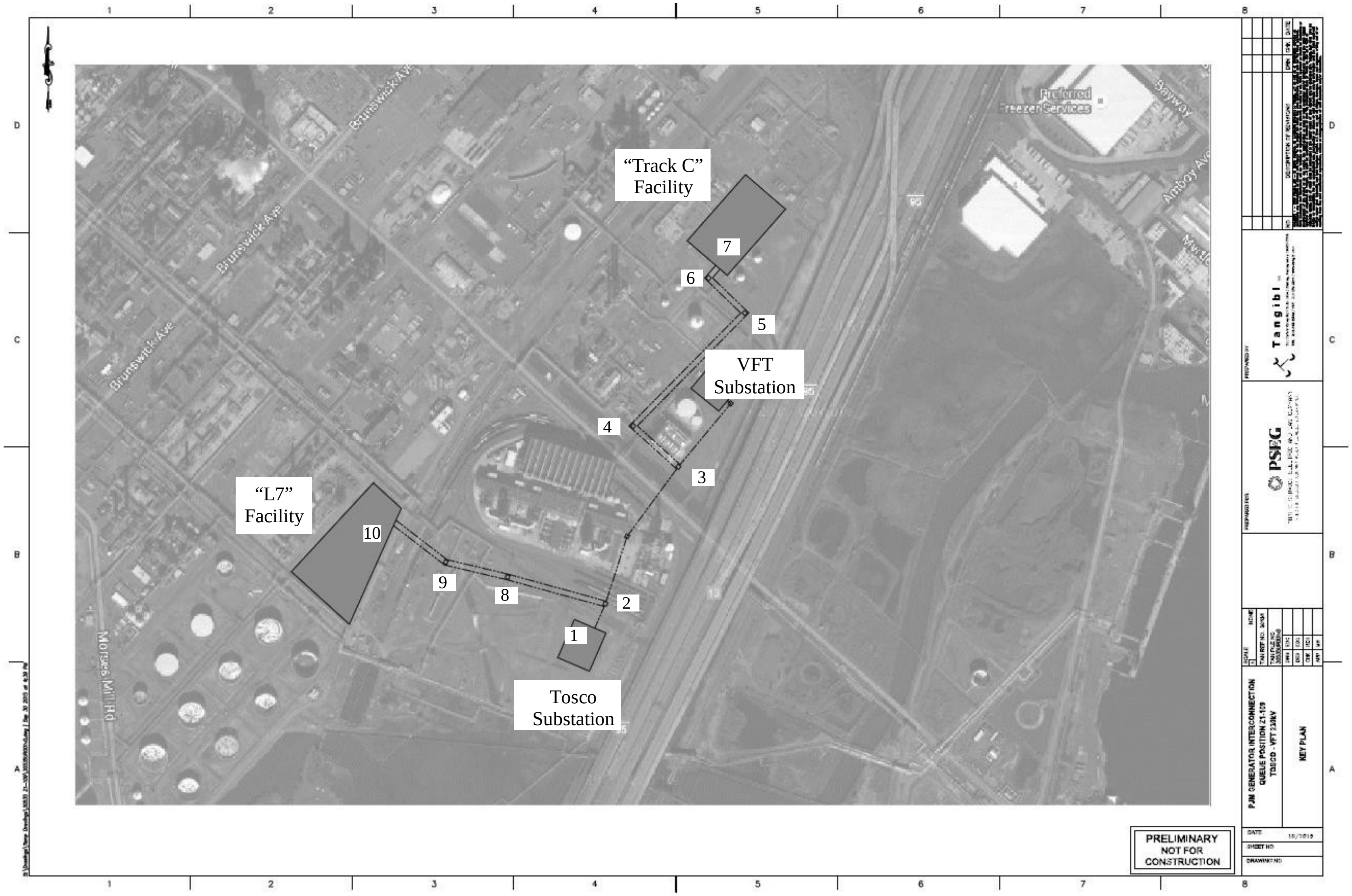
7. Information Required for Interconnection Service Agreement

Network Upgrade Number	Network Upgrade Type	Description	Direct Labor	Direct Materials	Indirect Labor	Indirect Materials and Equipment	Base Costs	Risk and Contingency	Total Cost	Z1-109 Allocation
	Attachment	Attachment Facilities - PSE&G ECP Substation	$103,425	$274,421	$119,578	$139,709	$637,133	$192,260	**$829,393**	**$829,393**
n4275	Direct	Direct Connection - PSE&G ECP Substation	$6,792,246	$7,462,255	$7,853,011	$3,964,519	$26,072,031	$7,822,576	**$33,894,607**	**$33,894,607**
n4275.1	Direct	Direct Connection - PSE&G Transmission Line	$1,898,052	$2,230,168	$978,265	$1,933,336	$7,039,822	$2,112,178	**$9,152,000**	**$9,152,000**
		Total Costs	**$8,793,723**	**$9,966,844**	**$8,950,854**	**$6,037,564**	**$33,748,986**	**$10,127,014**	**$43,876,000**	**$43,876,000**

Note: This table assumes construction of the facility at the "Track C" location.

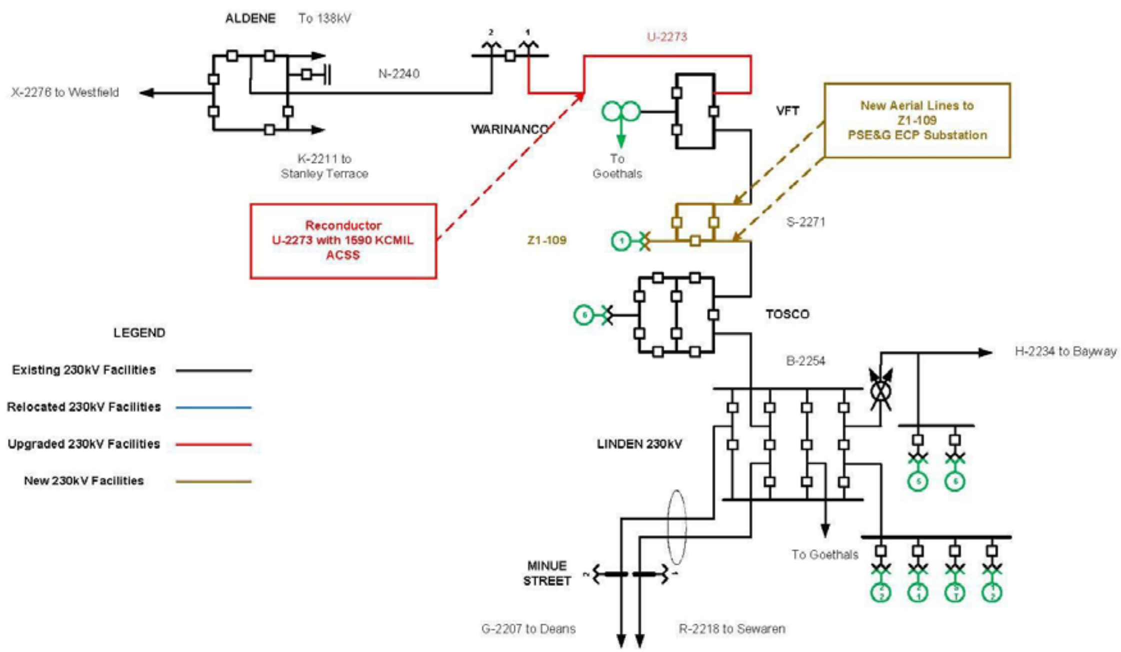
Attachment 1

Key Plan



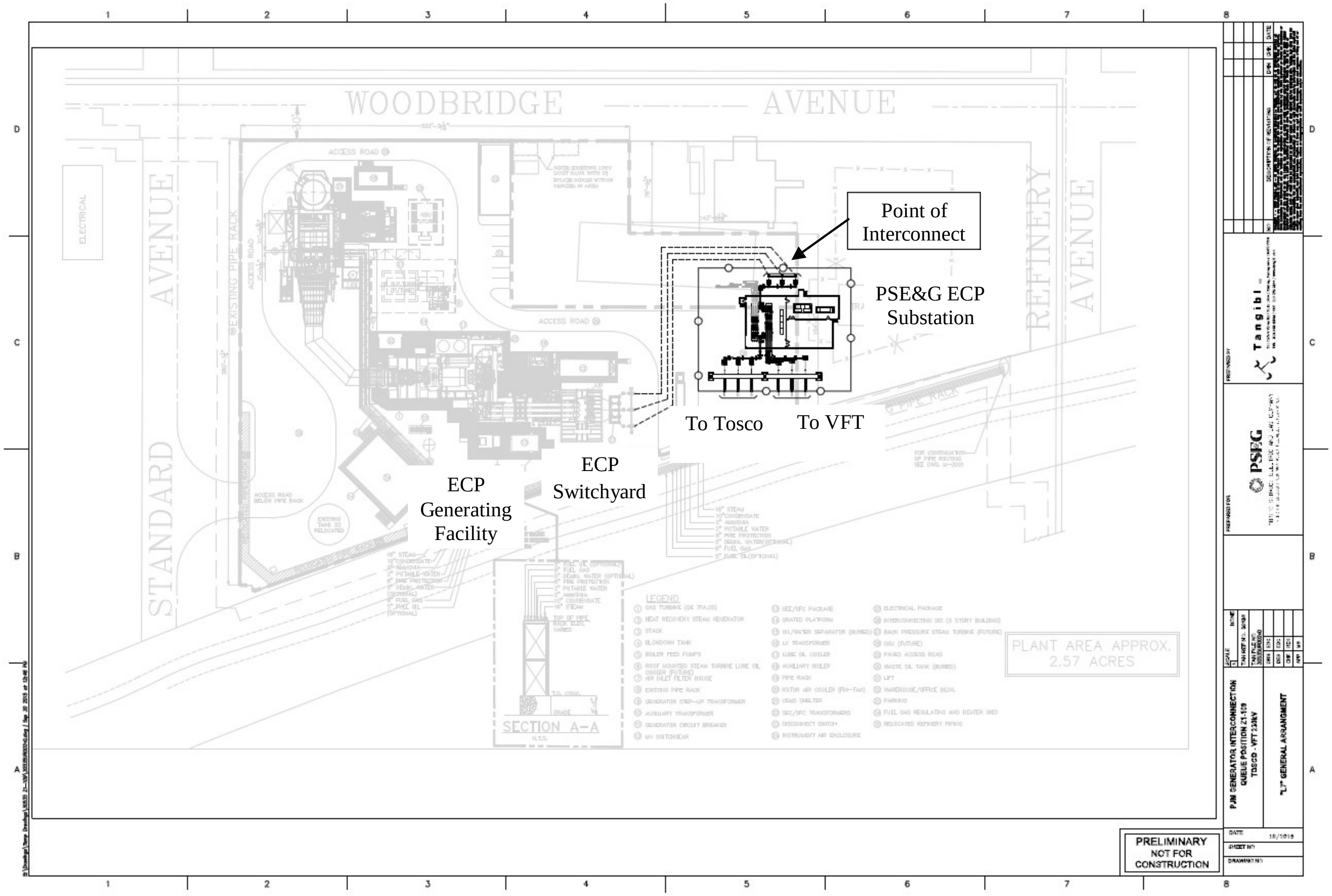
Attachment 2

Single-Line Diagram



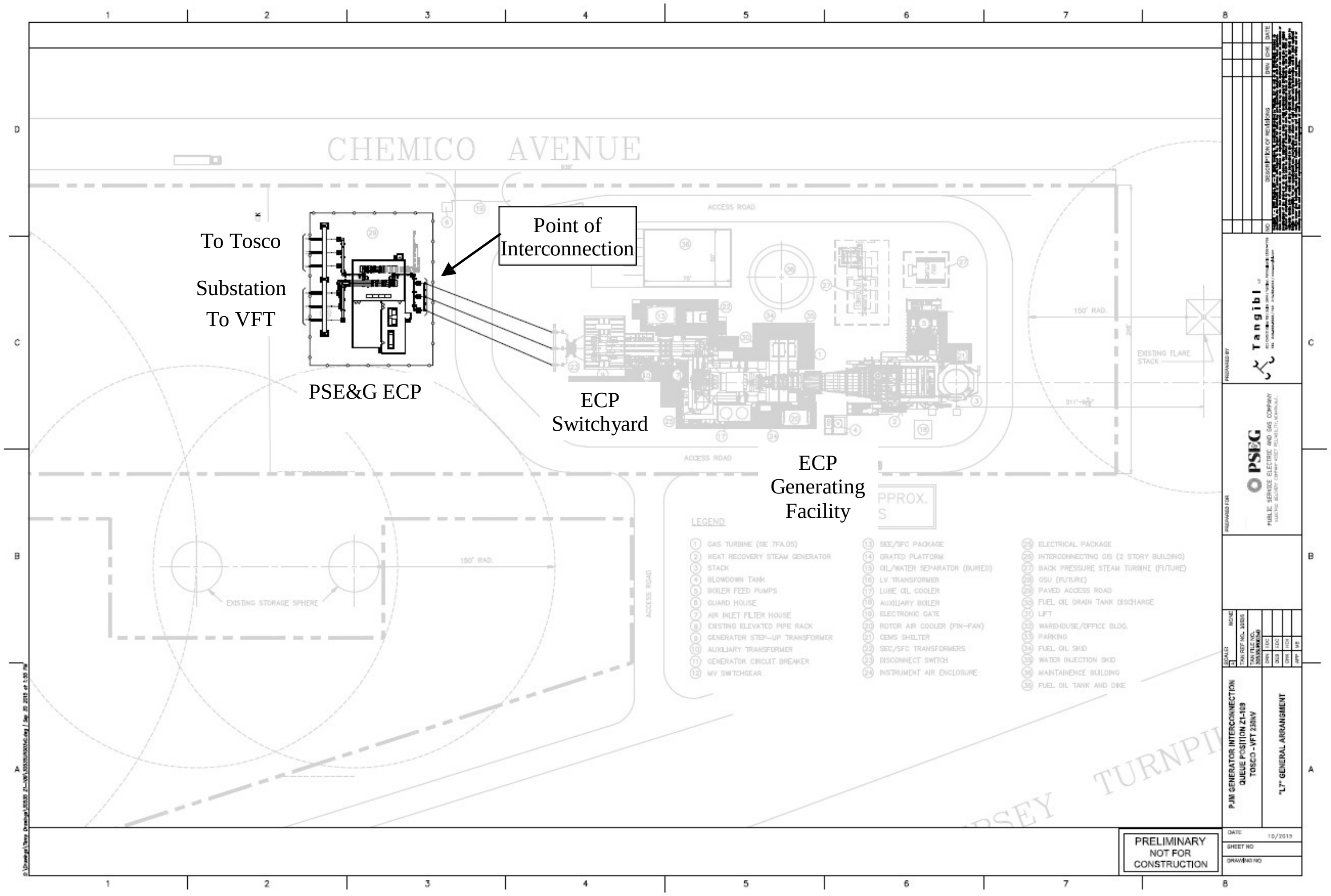
Attachment 3

"L7" Interconnection General Arrangement



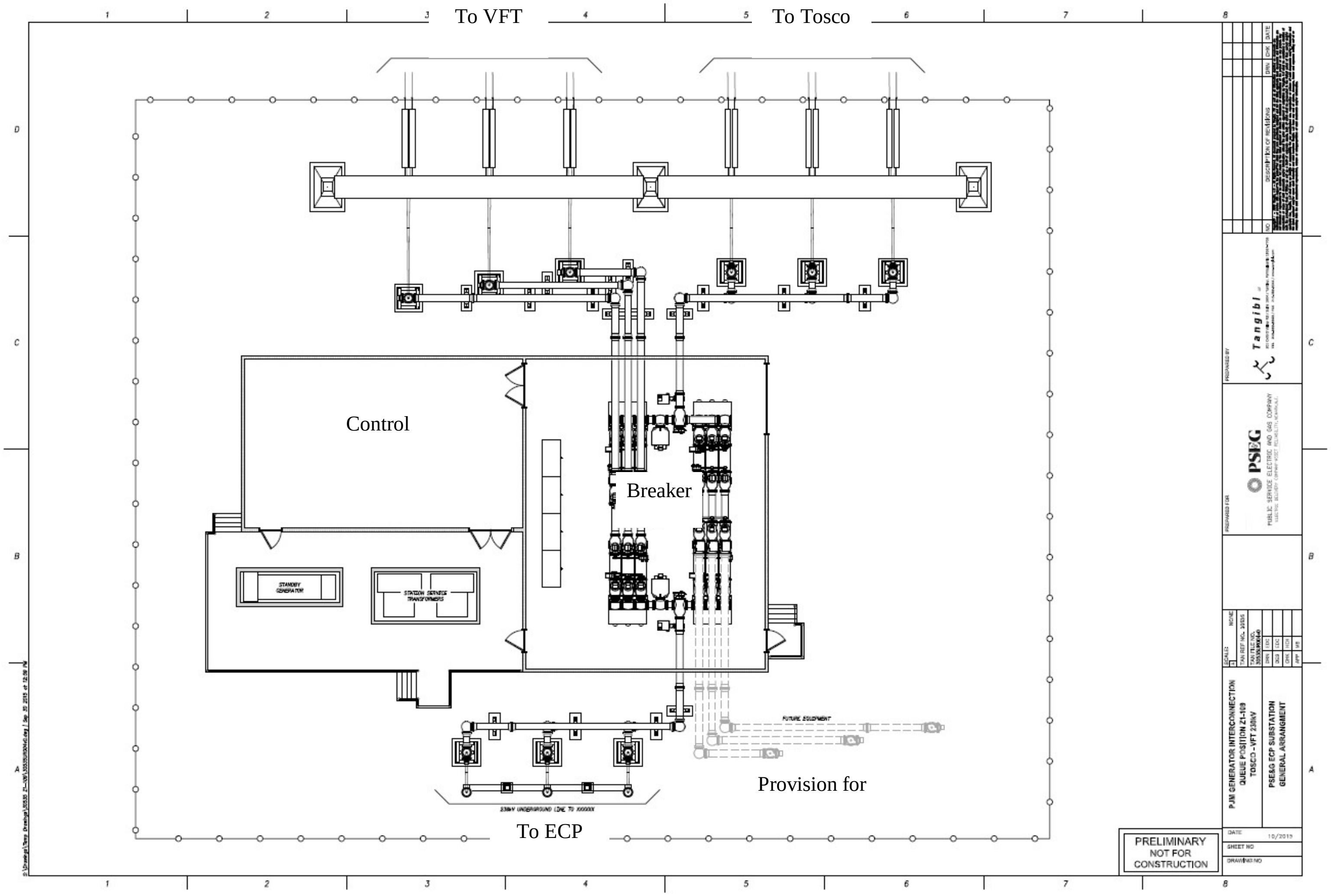
Attachment 4

"Track C" Interconnection General Arrangement



Attachment 5

PSE&G ECP Substation General Arrangement



Attachment 6

Z1-109 Stability Study

Transient Stability Study
Z1-109

TOSCO - VFT 230 kV

01/11/2016

Description

PJM queue project Z1-109 is a new interconnection request tapping the existing 230 kV line (S2271) between TOSCO and VFT substations in the PSEG system. This is a natural gas generating facility with a net output capability of 208 MW.

Stability analysis for the Z1-109 queue project was performed at 2017 light load conditions. The range of contingencies evaluated was limited to that necessary to assess compliance with the PSEG criteria. Simulation time was limited to 10 seconds for all faults.

Three fault types were considered in this study:

- Type A: Three-phase faults (3ph) with primary clearing time
- Type B: Stuck breaker fault cleared with backup clearing time
- Type C: Zone 2 faults cleared with secondary protection

Specific fault descriptions and breaker clearing times used for this study are provided in Appendix A.

Results

Transient Stability:

Under certain contingencies, oscillations in the monitored parameters were noted. The oscillations mostly originate from the Linden units CT5 and CT6. It was identified in the combined study for the queue projects Y3-046, Y3-051, Z1-058 and Z1-059 that stabilizers are needed at the Linden CT5 and CT6 to adequately damp out oscillations during post recovery. Since this project is in the vicinity of Linden, the simulations were carried out assuming stabilizers at the said machines.

There is a small unit at Aldene (bus #218307), which has been modeled without any reactive power capability. A small scale drift in the rotor angle and the reactive power output of this machine was noted. However, the post fault recovery of the real power output is adequate as it stabilizes within 10 seconds.

Oscillations of small amplitude were also identified at the Linden machines C001 (buses 218435 and 218436). The damping ratio of the rotor angle of the machine at 218436 was found to be 2.6% at 1.5 Hz which is below the criteria. After reviewing this, it was observed that the said units were dispatched well into leading region. Adjusting the voltage (and subsequently the reactive power) gave a case with a clean response. The voltage was adjusted to reflect typical operating conditions. The initial conditions for both scenarios are provided below.

Machine (bus no.)	Initial Conditions		Revised Conditions	
	Terminal Voltage	Reactive Power	Terminal Voltage	Reactive Power
218435	0.962	-64 Mvar	1.025	-9.3 Mvar
218436	0.983	-102 Mvar	1.018	+10.4 Mvar

Under the contingency 7b, the simulation plots show a steady drift in the rotor angle of certain machines. In this regard, the following should be noted:

- The machines at buses 218379, 292112, 292680, 902651 and 905641 are all 10 MVA or less. For that reason they are being gnetted within the skeleton and hence no angle. So, the angles in the plots are all the same, and correspond to the reference machine and not the relative angle between the unit and the reference.
- The machines at 907438 and 907437 represent HVDC (X1-078 project). The rotor angle channel is not a good metric as there is no rotor angle and whatever quantity being there is just a place holder. The real and reactive power are ok.

With the above observation, transient stability is maintained in all the contingencies simulated. Also, the voltage levels returned to normal for all cases following the fault clearance. Hence, no transient stability issues were concluded.

The maximum angle deviations for all three fault types are shown in Tables I - III.

Table I. Maximum Angle Deviation for Type A Faults
2017 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1A	297	913183	1	157.6	28.9	0.4084
2A	297	913183	1	157.6	27.7	0.4000
3A	280	218418	1	170.0	29.7	0.4500
4A	280	218418	1	170.0	28.7	0.4459
5A	280	218418	1	170.0	29.1	0.4459
6A	280	218418	1	170.0	28.4	0.4417
7A	280	218418	1	170.0	29.0	0.4459
8A	280	218418	1	170.0	27.4	0.4334
9A	271	218307	1	131.8	30.3	9.9882
10A	271	218307	1	131.8	23.7	0.2625
11A	280	218418	1	170.0	13.8	0.4209
12A	271	218307	1	131.8	23.9	0.2667

Table I. Maximum Angle Deviation for Type A Faults
2017 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
13A	280	218418	1	170.0	24.2	0.4375
14A	297	913183	1	157.6	28.7	0.4000
15A	297	913183	1	157.6	25.8	0.3792

Table II. Maximum Angle Deviation for Type B Faults
2017 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1B	281	218419	1	170.0	-20.7	0.9626
2B	278	218376	1	105.4	-12.4	9.9799
3B	280	218418	1	170.0	33.6	0.5417
4B	280	218418	1	170.0	33.2	0.5459
5B	280	218418	1	170.0	32.1	0.5334
6B	283	218424	1	166.9	-32.8	1.521
7B	271	218307	1	131.8	-44.1	9.9799
8B	280	218418	1	170.0	31.2	0.5292
9B	271	218307	1	131.8	27.1	9.9799
10B1	289	218468	1	160.3	-12.1	0.8959
10B2	289	218468	1	160.3	-12.1	0.9042
11B1	289	218468	1	160.3	-11.9	0.8959
11B2	278	218376	1	105.4	11.8	0.6459
12B1	278	218376	1	105.4	11.5	0.6459
12B2	271	218307	1	131.8	22.9	9.9799
13B	298	916603	1	152.6	-24.2	0.9251
14B	283	218424	1	166.9	-23.4	1.5001
15B	283	218424	1	166.9	-23.1	2.0835

Table III. Maximum angle deviation for type C faults
2017 Light Load Conditions

Fault	Chan	Bus	ID	Initial Angle	Max Deviation	Time
1C	298	916603	1	152.6	32.9	0.6876
2C	298	916603	1	152.6	-30.1	1.9085
3C	280	218418	1	170.0	-41.8	1.1834
4C	281	218419	1	170.0	-8.7	0.9417
6C	281	218419	1	170.0	-20.4	0.9959
9C	271	218307	1	131.8	23.0	9.9924
10C	281	218419	1	170.0	-14.6	0.9876
13C	298	916603	1	152.6	-30.2	1.9293
14C	280	218418	1	170.0	-35.4	1.1543

The new generator was modeled with GSU connected to a new local 230 kV bus, which is connected to the tap point on the existing TOSCO-VFT 230 kV Line. The terminal voltages of the generators were set at about 1.000 pu such that the plant was drawing 39 Mvar from the main system under steady-state load flow conditions.

Note: While the stability analysis has been performed at extreme system conditions, there is a potential that evaluation at a different level of generator MW and/or MVAR output at different system load levels and operating conditions may disclose unforeseen stability problems. The regional reliability analysis routinely performed to test all system changes will include one such evaluation. Any problems uncovered in that or other operating or planning studies will need to be resolved.

Moreover, when the proposed generating station is designed and plant specific dynamics data for the plant and its controls are available, and if it is different than the data provided for this study, a transient stability analysis at a variety of expected operating conditions using the more accurate data shall be performed to verify impact on the dynamic performance of the system. As more accurate or unit specific dynamics data for the proposed facility, as well as plant layout become available, it must be forwarded to PJM.

APPENDIX A
Z1-109
(TOSCO - VFT 230 kV)

A.1) POWER FLOW CONDITIONS

2017 Light Load Base Case

A.2) BREAKER CLEARING TIMES (CYCLES)

Table A.1. PSEG Clearing Times (Cycles)

Station	Primary (3ph/slg)	Stuck Breaker (Total)	Zone 2 (Total)	Re-closing
345 kV	4	17	34	N/A
230 kV	5	17	34	N/A
138 kV	6	18	34	N/A

A.3) NETWORK CONDITIONS

All facilities in service (base case)

A.4) FAULTS CONSIDERED

Note: For simplicity of fault type identification, PJM *has adopted the following notation:*

A faults: *three-phase faults with normal clearing time*
B faults: *slg faults due to stuck breaker with delayed clearing time*
C faults: *slg faults with delayed clearing time due to protection system failure*

This notation is for internal purposes only, and does not necessarily correspond with the NERC category definition stated in TPL-001.

<u>Z1-109 230 kV</u>

1a 3ph fault @ Z1-109 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Z1-109 - VFT 230 kV Ckt-2271

1b slg fault @ Z1-109 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Z1-109 - VFT 230 kV Ckt-2271
Breaker Failure
slg fault @ Z1-109 230 kV

Fault cleared within 230 kV breaker backup clearing time
Loss of: Z1-109

1c slg fault @ 80% of Z1-109 - VFT 230 kV Ckt-2271
VFT breaker tripped within 230 kV primary time
Z1-109 breakers tripped within 230 kV secondary time
Loss of: Z1-109 - VFT 230 kV Ckt-2271

2a 3ph fault @ Z1-109 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Z1-109 - TOSCO 230 kV Ckt-2271

2b slg fault @ Z1-109 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Z1-109 - TOSCO 230 kV Ckt-2271
Breaker Failure
slg fault @ Z1-109 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Z1-109

2c slg fault @ 80% of Z1-109 - TOSCO 230 kV Ckt-2271
TOSCO breaker tripped within 230 kV primary time
Z1-109 breakers tripped within 230 kV secondary time
Loss of: Z1-109 - VFT 230 kV Ckt-2207

<u>Linden 230 kV</u>

3a 3ph fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden - TOSCO 230 kV Ckt-2254

3b slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden - TOSCO 230 kV Ckt-2254
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Line - Deans 230 kV Ckt-2207

3c slg fault @ 80% of Linden - TOSCO 230 kV Ckt-2254
TOSCO breakers tripped within 230 kV primary time
Linden breakers tripped within 230 kV secondary time
Loss of: Linden - TOSCO 230 kV Ckt-2254

4a 3ph fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time

Loss of: Linden - Minue St. - Deans 230 kV Ckt-2207
Minue St. 230/13 kV transformer #2

4b slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Minue St. - Deans 230 kV Ckt-2207
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Linden - Minue St.230 kV Ckt-2207
Minue St. 230/13 kV transformer #2
Linden - Tosco 230 kV Ckt-2254

4c slg fault @ 80% of Linden - Minue St. - Deans 230 kV Ckt-2207
Deans breaker tripped within 230 kV primary time
Linden breakers tripped within 230 kV secondary time
Loss of: Linden - Minue St. - Deans 230 kV Ckt-2207
Minue St. 230/13 kV transformer #2

5a 3ph fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden - Geothals 230 kV Ckt-2253

5b slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden - Geothals 230 kV Ckt-2253
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Linden 230/138 kV transformer

6a 3ph fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden - Minue St. - Sewaren 230 kV Ckt-2218
Minue St. 230/13 kV transformer #1

6b slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Minue St. - Sewaren 230 kV Ckt-2218
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Linden - Minue St. 230 kV Ckt-2218
Minue St. 230/13 kV transformer #1
Linden Units 5 & 6

6c slg fault @ 80% of Linden - Minue St. - Sewaren 230 kV Ckt-2218
Sewaren breaker tripped within 230 kV primary time
Linden breakers tripped within 230 kV secondary time
Loss of: Linden - Minue St. - Sewaren 230 kV Ckt-2218
Minue St. 230/13 kV transformer #1

7a 3ph fault @ Linden 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Linden 345/230 kV transformer #1

7b slg fault @ Linden 230 kV
Fault cleared within 345 kV breaker primary clearing time
Loss of: Linden 345/230 kV transformer #1
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Linden CT1, CT2, CT3 and ST1

8a 3ph fault @ Linden 230 kV
Fault cleared within 138 kV breaker primary clearing time
Loss of: Linden 230/138 kV Transformer #2

8b slg fault @ Linden 230 kV
Fault cleared within 138 kV breaker primary clearing time
Loss of: Linden 230/138 kV Transformer #2
Breaker Failure
slg fault @ Linden 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Linden - Geothals 230 kV Ckt-2253

<u>VFT 230 kV</u>

9a 3ph fault @ VFT 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: VFT-1 - Warinaco 230 kV Ckt-2273
Warinaco 230/13 kV Transformer #1

9b slg fault @ VFT 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: VFT-1 - Warinaco 230 kV Ckt-2273
Warinaco 230/13 kV Transformer #1
Breaker Failure
slg fault @ VFT 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: VFT 230 kV

9c slg fault @ 80% of VFT-1 - Warinaco 230 kV Ckt-2273
Warinaco breaker tripped within 230 kV primary time
VFT breakers tripped within 230 kV secondary time
Loss of: VFT-1 - Warinaco 230 kV Ckt-2273

Aldene 230 kV

10a 3ph fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Westfield 230 kV Ckt-2276
Westfield 230/13 kV Transformer #2
Aldene 230/26 kV transformer

10b1 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Westfield 230 kV Ckt-2276
Westfield 230/13 kV Transformer #2
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene 230/13 kV Transformer #20
Aldene 230/26 kV transformer

10b2 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Westfield 230 kV Ckt-2276
Westfield 230/13 kV Transformer #2
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene 230 kV Bus #3
Aldene - Stanley Terrace 230 kV Ckt-2211
Aldene 230/26 kV transformer

10c slg fault @ 80% of Aldene - Westfield 230 kV Ckt-2276
Westfield breaker tripped within 230 kV primary time
Aldene breakers tripped within 230 kV secondary time
Loss of: Aldene - Westfield 230 kV Ckt-2276

11a 3ph fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Stanley Terrace 230 kV Ckt-2211
Aldene 2 Unit

11b1 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time

Loss of: Aldene - Stanley Terrace 230 kV Ckt-2211
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene 230 kV Bus #2
Aldene 230/26 kV Transformer #3
Aldene-2 Unit
Aldene - Westfield 230 kV Ckt-2276

11b2 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Stanley Terrace 230 kV Ckt-2211
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene 230 kV Bus #2
Aldene-2 Unit
Aldene - Springfield Rd. 230 kV Ckt-2285

12a 3ph fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Springfield Rd. 230 kV Ckt-2285
Springfield Rd. 230/13.8 kV Transformer-2
Aldene 230/13 kV Transformer-10

12b1 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Springfield Rd. 230 kV Ckt-2285
Springfield Rd. 230/13.8 kV Transformer-2
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene - Stanley Terrace 230 kV Ckt-2211
Aldene 230/13 kV Transformer-10
Aldene-2 Unit

12b2 slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Aldene - Springfield Rd. 230 kV Ckt-2285
Springfield Rd. 230/13.8 kV Transformer-2
Breaker Failure
slg fault @ Aldene 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Aldene - Warinaco 230 kV Ckt-2240
Aldene 230/13 kV Transformer-10

Tosco 230 kV

13a 3ph fault @ Tosco 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Tosco - Linden 230 kV Ckt-2254

13b slg fault @ Tosco 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Tosco - Linden 230 kV Ckt-2254
Breaker Failure
slg fault @ Tosco 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Tosco - VFT 230 kV Ckt-2271
Tosco 230 kV (due to island)

13c slg fault @ 80% of Tosco - Linden 230 kV Ckt-2254
Linden breakers tripped within 230 kV primary time
Tosco breakers tripped within 230 kV secondary time
Loss of: Tosco - Linden 230 kV Ckt-2254

14a 3ph fault @ Tosco 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Tosco - Z1-109/VFT 230 kV Ckt-2271

14b slg fault @ Tosco 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Tosco - Z1-109/VFT 230 kV Ckt-2271
Breaker Failure
slg fault @ Tosco 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Tosco - Linden 230 kV Ckt-2254
Tosco 230 kV (due to island)

14c slg fault @ 80% of Tosco - Z1-109/VFT 230 kV Ckt-2271
Z1-109 breakers tripped within 230 kV primary time
Tosco breakers tripped within 230 kV secondary time
Loss of: Tosco - Z1-109/VFT 230 kV Ckt-2271

15a 3ph fault @ Tosco 230 kV
Fault cleared within 230 kV breaker primary clearing time
Loss of: Tosco 23/26 kV transformer TR-1

15b slg fault @ Tosco 230 kV
Fault cleared within 26 kV breaker primary clearing time
Loss of: Tosco 23/26 kV transformer TR-1

Breaker Failure
slg fault @ Tosco 230 kV
Fault cleared within 230 kV breaker backup clearing time
Loss of: Tosco Unit-6

Note: In the LF base-case, the 230/26 kV transformers at Tosco are out of service. The contingency 15a is therefore redundant but included for consistency. A stuck breaker (230-5 or 230-6) at Tosco would lead to outage of the Tosco unit.

A.4.1) Maintenance outage faults

No faults with outages due to maintenance were studied.

A.5) Reinforcements

The following reinforcements were considered in the study:

None

APPENDIX B

Z1-109 Plant Model

	Impact Study Data	Model
Z1-109 turbine generator	232.0 MW combustion turbine generator MVA base = 277 MVA Vt = 18.0 kV Saturated sub-transient reactance j0.220 pu @ MVA base	212.9 MW generator1 Pgen 212.9 MW Pmax 212.9 MW Pmin 84.0 MW Qgen 10.2 MVAr Qmax 130 MVAr Qmin -65 MVAr Mbase 277 MVA Zsorce 0.0034 + j0.2200 pu @ 277 MVA
Z1-109 turbine GSU	345.0/18.0 kV 150/200/250 MVA OA/F1/F2 Transformer base = 150 MVA Impedance = 0.00168 + j0.13999 % @ 150 MVA Number of taps = 5 Tap step size = 2.5%	345.0/18.0 kV 150/200/250 MVA OA/F1/F2 Transformer base = 150 MVA Impedance = 0.00168 + j0.13999 % @ 150 MVA Number of taps = 5 Tap step size = 2.5%
Z1-109 dummy transformer	345.0/230.0 kV Transformer base = 100 MVA Impedance = 0.0000 + 0.0001 pu Number of taps = N/A Tap step size = N/A	345.0/230.0 kV Transformer base = 100 MVA Impedance = 0.0000 + 0.0001 pu Number of taps = N/A Tap step size = N/A
Z1-109 turbine auxiliary load	4.9 MW + 0.0 MVAr at low voltage side of GSU	4.9 MW + 0.0 MVAr at low voltage side of GSU
Transmission line	Not provided	N/A

Dynamic Data

```
1     PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS®E      THU, NOV 12 2015  10:44


 PLANT MODELS

 REPORT FOR ALL MODELS                    BUS 916603 [Z1-109 GEN  18.000] MODELS


 ** GENROU **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
           916603 Z1-109 GEN   18.000 1  110497-110510  45420-45425

            MBASE     Z S O R C E         X T R A N       GENTAP
            277.0  0.00340+J 0.22000  0.00000+J 0.00000  1.00000

  T'D0 T''D0  T'Q0 T''Q0     H   DAMP   XD     XQ     X'D    X'Q   X''D    XL
  7.91 0.039  0.63 0.076   5.86  0.00 2.4000 2.2800 0.2950 0.5000 0.2200 0.0000

                               S(1.0)  S(1.2)
                               0.0752  0.6835


 ** PSS2A  **   BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S      I C O N S
           916603 Z1-109 GEN   18.000 1  136024-136040  66210-66225   21355-21358   11255-11260

                  IC1 REMBUS1     IC2 REMBUS2       M       N
                    1       0       3       0       5       1

      TW1      TW2      T6       TW3      TW4      T7       KS2      KS3
     2.000    2.000    0.000    2.000    0.000    2.000    0.171    1.000

      T8       T9      KS1       T1       T2       T3       T4      VSTMAX   VSTMIN
     0.500    0.100   10.000    0.150    0.030    0.150    0.030    0.100   -0.100


 ** ESST4B **  BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S
           916603 Z1-109 GEN   18.000 1  246633-246649  96461-96464

    TR    KPR     KIR     VRMAX    VRMIN    TA     KPM     KIM    VMMAX   VMMIN
   0.200   3.600   3.600   1.000  -0.870   0.020   1.000   0.000   1.000  -0.870

            KG      KP      KI   VBMAX     KC      XL    THETAP
          0.000   5.550   0.000   6.940   0.080  0.0000   0.000


  **  GGOV1 ** BUS X-- NAME --X BASEKV MC    C O N S     S T A T E S     V A R S        ICONS
           916603 Z1-109 GEN   18.000 1  328026-328058 123103-123112  48100-48120   15822-15823

    R    TPELEC   MAXERR  MINERR  KPGOV   KIGOV   KDGOV   TDGOV    VMAX    VMIN
   0.040   1.000   0.050  -0.050  10.000   2.000   0.000   1.000   1.000   0.150

    TACT   KTURB    WFNL     TB      TC     TENG   TFLOAD  KPLOAD   KILOAD  LDREF
   0.500   1.500   0.200   0.100   0.000   0.000   3.000   2.000   0.670   1.000

    DM    ROPEN  RCLOSE    KIMW    ASET      KA      TA    TRATE    DB
  -2.000   0.100  -0.100   0.000   0.010  10.000   0.100 225.000   0.000

    TSA     TSB     RUP    RDOWN
   4.000   4.000  99.000 -99.000


              ICON(M)= 1 (Feedback signal for governor droop)
              ICON(M+1)= 1 (Switch for fuel source characteristic)
```