PJM Generator Interconnection Z1-108 McHenry 20MWe Feasibility/System Impact Study

May 2014

DMS # 793221v1

Preface

The intent of the Feasibility/System Impact Study is to determine a plan, with approximate cost and construction time estimates, to connect the subject generation interconnection project to the PJM network at a location specified by the Interconnection Customer. As a requirement for interconnection, the Interconnection Customer may be responsible for the cost of constructing: Network Upgrades, which are facility additions, or upgrades to existing facilities, that are needed to maintain the reliability of the PJM system. All facilities required for interconnection of a generation interconnection project must be designed to meet the technical specifications (on PJM web site) for the appropriate transmission owner.

In some instances an Interconnection Customer may not be responsible for 100% of the identified network upgrade cost because other transmission network uses, e.g. another generation interconnection or merchant transmission upgrade, may also contribute to the need for the same network reinforcement. 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 System Impact Study is performed.

The Feasibility/System Impact 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.

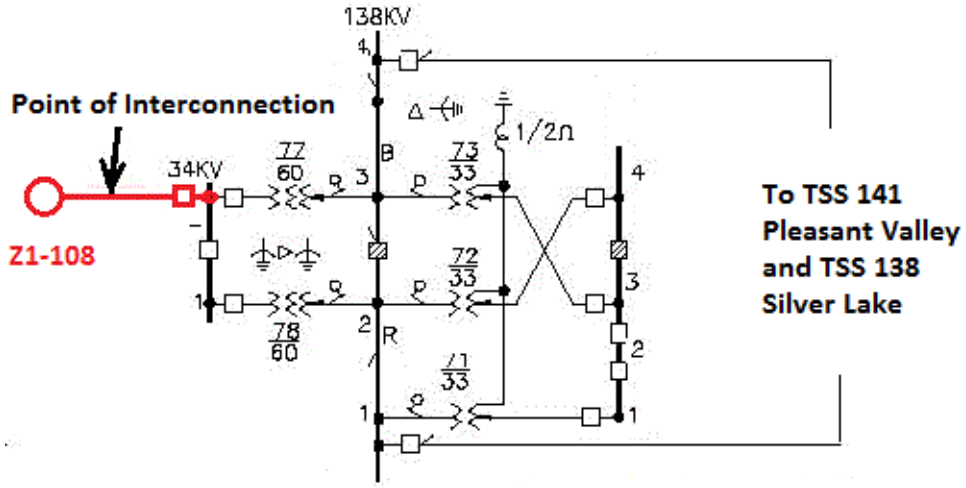
General

Queue Z1-108 is a McHenry Battery Storage LLC. ("Interconnection Customer"), request to interconnect a new 20 MW (energy only) energy storage facility (batteries). The Customer Facility will be located in McHenry, Illinois. The Interconnection Customer's planned in-service date for Queue Z1-108 generation is October 1, 2014.

This project was eligible to enter the Alternate Queue Process discussed in section 112.5 of the Tariff. It met all of the following criteria, as required: (i) project is not connected to a PJM monitored transmission facility as defined in PJM Manual M-03, (ii) project is not be an uprate or addition to an existing facility, (iii) project distribution factor for any PJM monitored transmission facility does not exceed 5 percent as evaluated against the case chosen to model the New Services Queue associated with the timing of the receipt of the Interconnection Request and the MW impact of the project is not be greater than 1 percent of the element rating, (iv) project does not connect to the same Point of Interconnection as any other project, and (v) aggregate impact of all projects connecting on any individual radial connection to a PJM monitored transmission facility does not exceed 1 percent of line rating.

Attachment Facilities

Queue Z1-108 will be connected to the TSS 193 McHenry Substation as shown on the single line diagram below.



Cost Estimates and Options

Description	Direct Material	Indirect Material	Direct Labor	Indirect Labor	Total Cost
Substation relief and new breaker & 34.5kV line.	$415,000	$50,000	$230,000	$205,000	$900,000
Telemetry, SCADA, and Metering	$119,000	$7,000	$66,000	$59,000	$251,000

Cost estimate for Figure 1-4 –with substation relief and new 34kV line built by ComEd.

Description	Direct Material	Indirect Material	Direct Labor	Indirect Labor	Total Cost
Install new breaker and new 34.5kV line to customer.	$300,000	$35,000	$190,000	$175,000	$700,000
Telemetry, SCADA, and Metering	$119,000	$7,000	$66,000	$59,000	$251,000

Cost estimate for figures 1 ,2 & corresponding notes on figure 4 – Plus the "Trip Automation" scheme since the estimate does not include substation relief. New line built by ComEd.

Description	Direct Material	Indirect Material	Direct Labor	Indirect Labor	Total Cost
Install new breaker with 34.5kV line to substation fence by GP.	$100,000	$14,000	$54,000	$32,000	$200,000
Telemetry, SCADA, and Metering	$119,000	$7,000	$66,000	$59,000	$251,000

Cost estimate – Includes "Trip Automation" scheme, since no substation relief. 34.5kV line to be built by Glidepath, up to ComEd substation fence.

This cost will be included in the IA between the developer and ComEd. ComEd has not completed a Relay and Protection Engineering review or a Wholesale Distribution Charge study. These pending efforts may reveal additional costs which will be communicated to the developer during the Facilities Study phase of the proposed project.

Local Impacts

The impact of the proposed generating facility on the ComEd system was assessed for adherence to ComEd's planning criteria at the 34.5kV line and 138kV/ 34.5kV substation level. The required system improvements discussed in this report (see Figure 1-4) are necessary in order to maintain proper thermal loading and contingency ability on all of the components of the ComEd system that are involved in serving this facility. Absent substation reinforcement, TSS 193 McHenry will experience a 1% thermal overload during summer peak loading conditions and a loss of one 60MVA transformer with the addition of the Glidepath facility. There are two alternative reinforcement plans described below:

1. Alternative 1: Substation Relief--- Figures 1 & 2 are required to accommodate the interconnection of the proposed facility. This includes a 34.5kV line build by ComEd from the source to the Glidepath facility, plus ComEd substation relief as shown in Figure 3.
2. Alternative 2: Trip Automation scheme-- Same as above excluding the substation relief on Figure 3 but in addition prior to connecting the proposed facility to TSS 193 McHenry, an agreement to automatically disconnect the proposed facility from TSS 193 McHenry upon the loss of one transformer at TSS 193 McHenry during summer peak conditions is required.

This study also assessed the ability of the proposed Energy Storage facility to operate at the proposed site without causing voltage disturbances outside of the limits required by ComEd—both for steady state operation and for fluctuations (flicker) resulting from changes in unit operating mode and charging or output magnitude. With the project in service, steady-state voltage must be maintained at all times within +/- 1% of 36kV. Based on the expected maximum rate of change of the PJM signal, the mode of operation of the proposed facility could change state as often as 30 times per minute. At this frequency, ComEd's standard requires that fluctuations in primary voltage at the point of customer interconnection must be kept below 1.1V on a 120V base
Normal and contingency configurations were studied under summer peak system loading conditions. Based on the unit parameters that were provided by the developer (see Unit

Assumptions below), the proposed facility is capable of operating at up to full charging demand and up to full output with the appropriate reactive compensation to adhere to both of these requirements under each of the following two cases:

1. Substation Relief---Figures 1 & 2 are required to accommodate the interconnection of the proposed facility. This includes a 34.5kV line build by ComEd from the source to the Glidepath facility, plus ComEd substation relief as shown in Figure 3.
2. Same as above excluding the substation relief on Figure 3 but in addition prior to connecting the proposed facility to TSS 193 McHenry, an agreement to automatically disconnect the proposed facility from TSS 193 McHenry upon the loss of one transformer at TSS 193 McHenry during summer peak conditions is required.

The proposed Energy Storage facility must monitor voltage at the point of interconnection and insure that the above voltage constraints are maintained at all times.

Unit Assumptions:

- Maximum Real Power in Charging Mode = 20MW
- Charging time at maximum real power = 22.5 minutes
- Maximum Real Power in Output Mode = 20MW
- Discharge time at maximum real power = 22.5 minutes
- Maximum Ramp Rate = 40MW / 167 milliseconds
- Reactive Capability = +/- 15MVAR at 20MW, +/- 25MVAR at 0MW
- Maximum Fault Current = 200% of rated current

Short Circuit

ComEd performed a short circuit study for this project at the distribution level and did not identify any issues. The maximum available 34.5kV RMS symmetrical fault current at the point of interconnection with the proposed Energy Storage facility in service are as follows:

16,000 Amps Three-Phase
18,000 Amps Single Line to Ground

New Local Reinforcements

The system reinforcements depicted in the drawings below are required in order to accommodate the interconnection of the proposed facility:

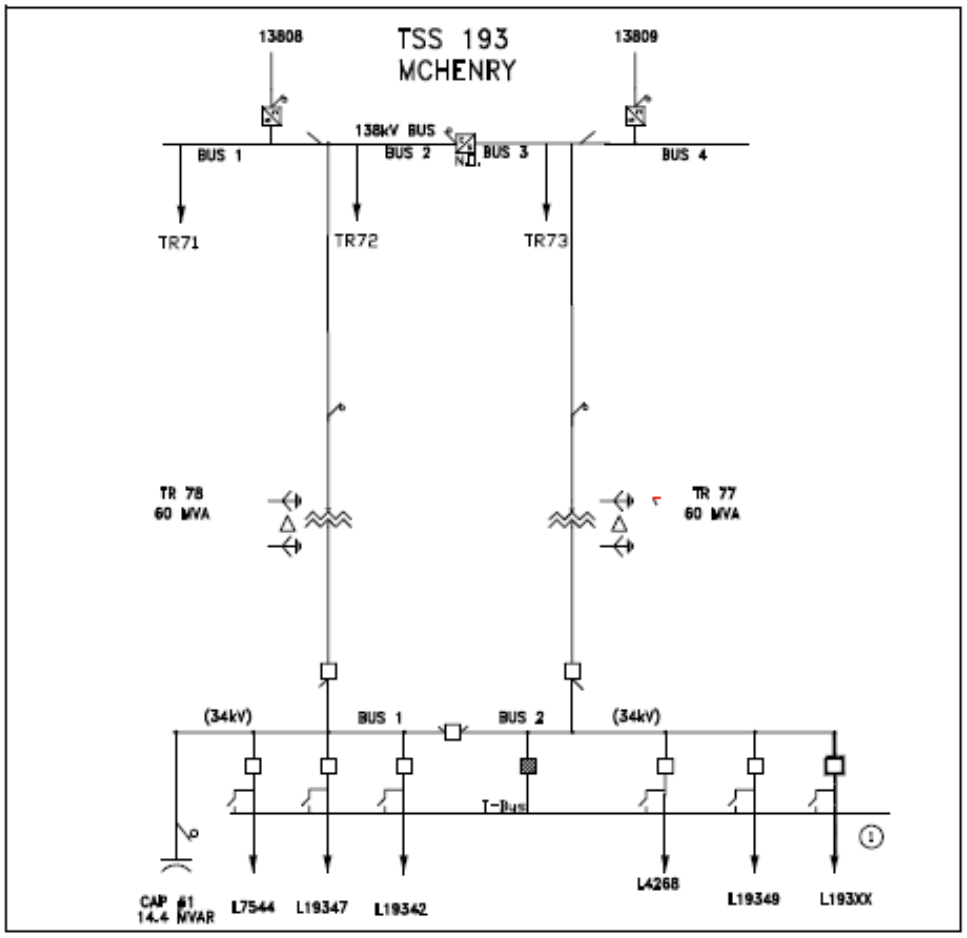


Figure 1 ComEd

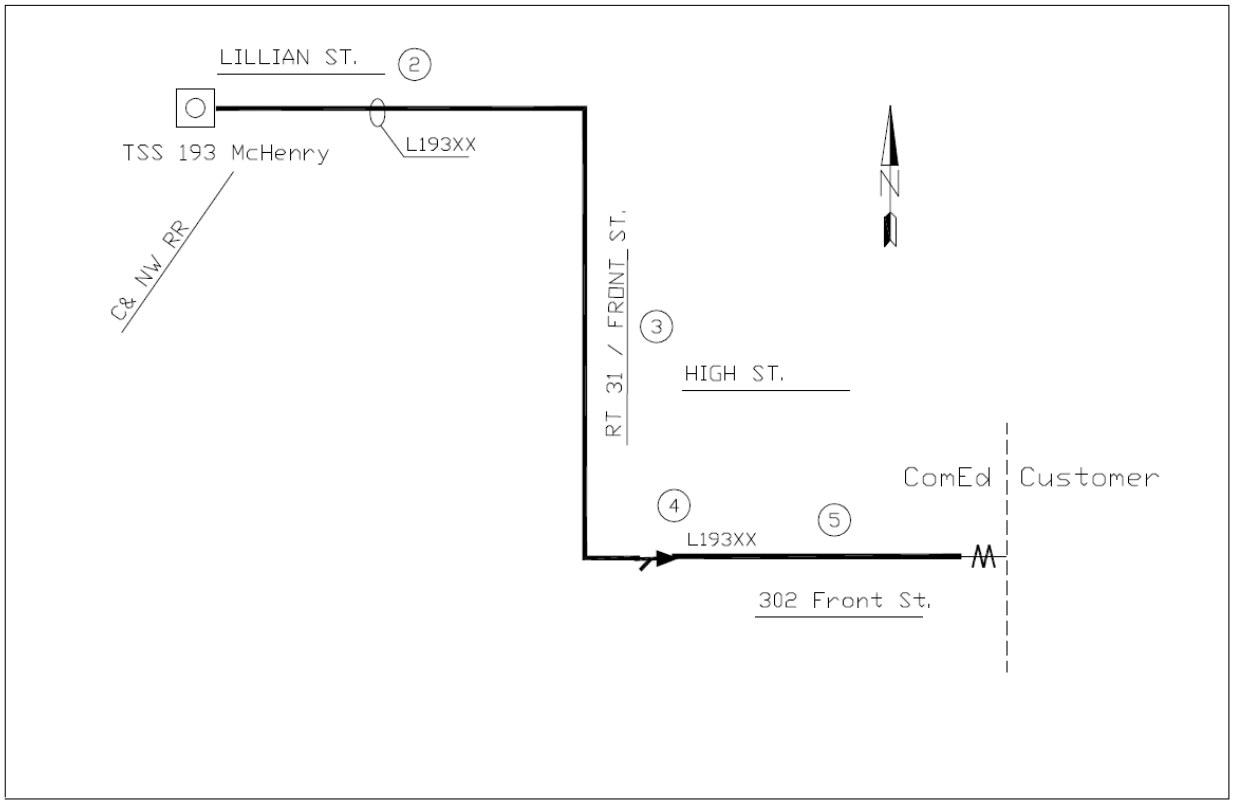


Figure 2 ComEd

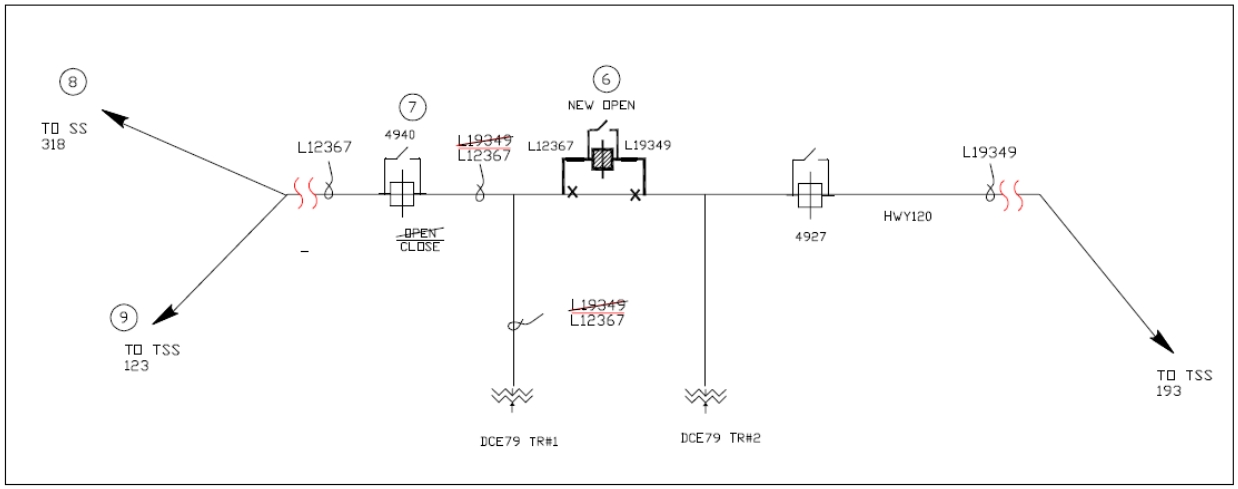


Figure 3 ComEd

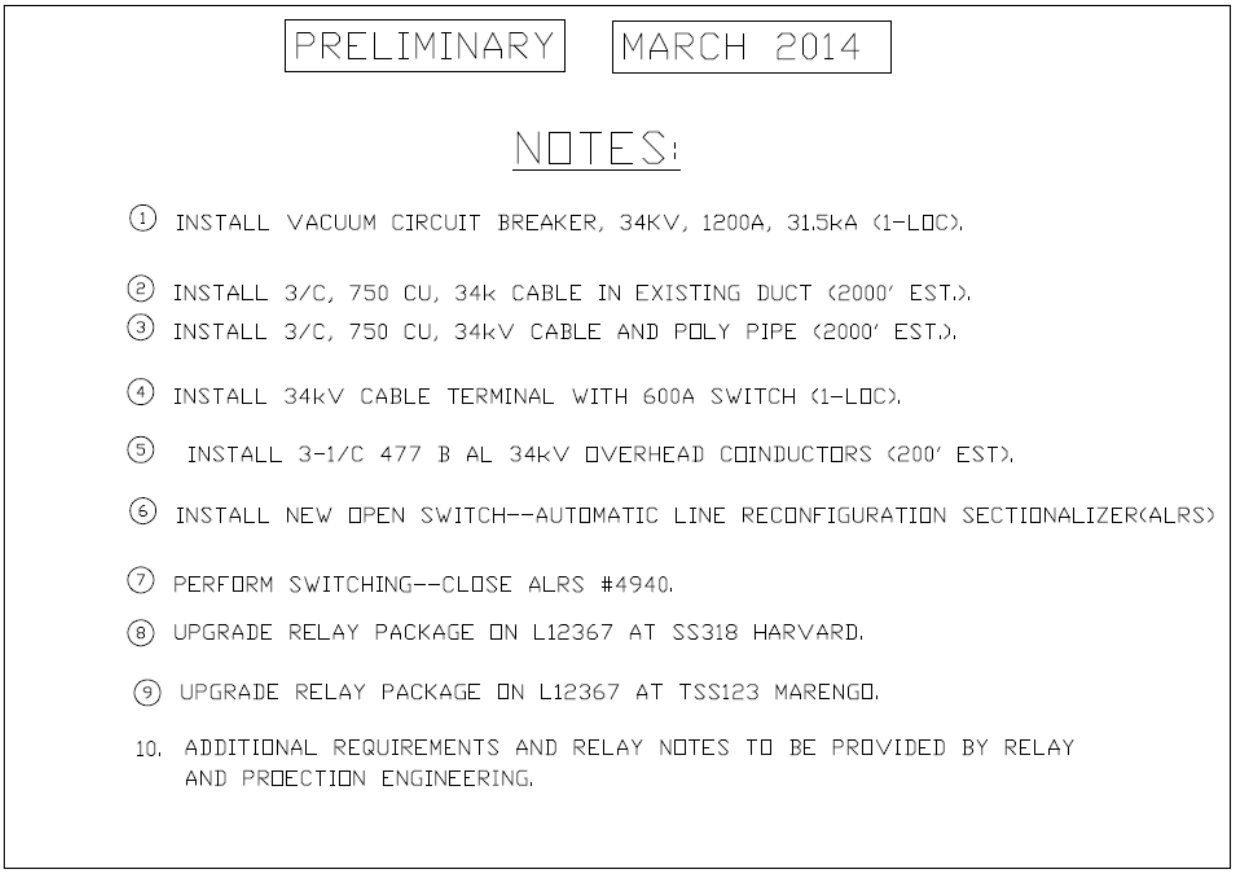


Figure 4 ComEd

Interconnection Customer Scope of Direct Connection Work

The Interconnection Customer is responsible for construction of all facilities on its side of the POI (Point of Interconnection).

Metering / telemetering

Interconnection Customer shall install Metering Equipment and telemetry equipment to provide revenue metering and real-time telemetry data to PJM in conformance with the requirements listed in PJM Manual 1, Section 3 and 5 and Manual 14D Section 4.

These can be found at http://www.pjm.com/documents/manuals.aspx .

See also Exelon Energy Delivery Interconnection Guidelines for Generators greater than 2 MVA but less than or equal to 20 MVA that can be found at https://www.comed.com/customer-service/rates-pricing/interconnection/Pages/transmission.aspx

Network Impacts

The queue Z1-108 project was studied as a 20.0MW energy injection into ComEd's system at the TSS 193 McHenry 34.0kV substation. Project Z1-108 was evaluated for compliance with reliability criteria for summer peak conditions in 2017. Potential network impacts were as follows:

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

No issues identified.

Multiple Facility Contingency
(Double Circuit Tower Line, Line with Failed Breaker and Bus Fault contingencies for the full energy output)

No issues identified.

Steady-State Voltage Requirements

(Results of the steady-state voltage studies should be inserted here)

None.

Stability and Reactive Power Requirement

Not required by PJM.

Short Circuit

Short circuit analysis does not need to be performed by PJM since the project is an inverter based (solar, flywheel, battery etc) project which will provide minimal fault current contribution to the transmission system.

New System Reinforcements

None required.

Contribution to Previously Identified System Reinforcements

None required.

Delivery of Energy Portion of Interconnection Request
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.
Only the most severely overloaded conditions are listed. 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 will study all overload conditions associated with the overloaded element(s) identified.

None identified.