



Feasibility Study for MHG (Savage) Solar LLC 2750 kW Solar Project GMP CID-88269 QP-683

**Located at 801 VT Route 103S in Chester, Vermont
Connected to the GMP CH-G11 Circuit at Line 3 Pole 84 Tag 489556**

**Allabaugh, Derek
4/12/2023**

Document Revision No.	Date	Author	Comments
0	3/31/2023	Derek Allabaugh	Creation of the document
1	4/13/2023	Derek Allabaugh	Update for fixing conflicting information

This document provides Green Mountain Power's results of its Feasibility analysis for the proposed Project. This Feasibility analysis complies with the Vermont Public Utility Commission's Rule 5.505 (B) Fast Track Screening Criteria. If the proposed Project fails a given criterion, supplemental analysis has been included. To the extent that the supplemental analysis confirms that the Project may have adverse impacts on safety or reliability, further study will be required.

SECTION 1

Project Description and Notes

Project and Distribution System Description

MHG (Savage) Solar LLC proposes to install a 2750kW-AC Solar (the Project) in Chester, Vermont. The Project requests to interconnect to Green Mountain Power (GMP) on the GMP CH-G11 distribution circuit in the vicinity of Line 3 Pole 84 Tag 489556 (the Point of Interconnection or POI). This circuit has a 7.2/12.47 kV grounded-wye configuration and is supplied by the GMP Chester substation. This substation serves the CH-G10 and CH-G11 circuits via one power transformer. The Project would be located approximately 2.99 circuit miles from the substation. The power transformer at the substation has a base/top nameplate rating of 7.5/10.5 MVA. The CH-G11 voltage is regulated via three 328-amp regulators connected one per phase.

As of March 15th, 2023, the application date for the Project, the total of installed and proposed distributed energy resources (DER) on the Chester substation was 8,024 kW, including the Project. The total DER on the CH-G11 was 6,943 kW, including the Project. There are no rotating machine generators on the CH-G11 circuit.

The existing installed and proposed projects shall be included in the analysis as part of the total or aggregate distributed resources as necessary.

Substation/Circuit Protection and Loading

Location	Equipment and Control Type	Maximum Loading (kW) ¹	Minimum Loading (kW) ¹	Total DER Proposed and Connected (kW)
Chester Power Transformer	46 kV 150PF, Southern States High Side Fuses	4,954 2/4/2023 11:30	30% of peak	8,024
CH-G11 Circuit	12.47 kV Breaker with electronic relays	2,795 2/3/2023 18:15	30% of peak	6,943

¹ Circuit level loads are two full years plus current year SCADA and AMI data, prior to application date. The amount of distributed generation on-line at the time of the peak was estimated and is included in these figures. Line loads are based on CymDIST load flow calculations.

Relevant Studies

There are no studies relevant to this Project.

Existing Materials

There is an existing CYMDIST unbalanced load flow model.

Modeling Assumptions:

- This Project has been studied with a 250 foot three-phase 1/0 15kV poly wire overhead line extension from the POI to the PCC.
- This Project has been studied as being served from its normal supply, in this case the CH-G11. There are alternate supplies to this location; and in the event of a resupply situation the Project may need to be taken off line for the duration of the resupply.
- The minimum daytime load was determined by analyzing the minimum loads during “daylight” hours between 8:00am and 4:00pm. This date generally falls within the spring and fall months of April, May, September, or October. Otherwise, a conservative estimate of 30% of the peak load will be noted and used.
- The modeling for this analysis utilizes the electrical one-line diagram submitted for the Project. The Project proposes to install a pad mounted 3000 kVA, 12470/7200 volt grounded-wye to 800/462 volt grounded-wye transformer. The impedance of the transformers is stated to be 5.75%.
- Unless otherwise specified, the power factor for PV projects is assumed to be 100% and the power factor for synchronous and induction generators is assumed to be +/-98%, and +/-93%, respectively.
- The short circuit contribution from the Project is assumed to be 150% of the Project’s AC capacity.
- The inverter connection type is a three phase, no or low impedance continuous bond to the GMP neutral, also known as an ineffectively grounded connection.
- The inverters shall be required to operate with a total demand distortion (TDD) that complies with IEEE 1547 which references IEEE 519 specifically for harmonic contribution limits.
- Regarding voltage flicker for inverter based PV systems; GMP finds that inrush current is not a significant indicator of sudden voltage drop as it would be for rotating machine generators. To measure the sudden change in voltage, GMP’s voltage flicker test for inverter based PV systems shall be used to test the impact of the Project to the distribution circuit. The voltage flicker test will consider the cloud shading effects on the PV modules. The cloud shading effect will consider the output drop of 70% for the PV system being studied, i.e. a drop in output from the nameplate ratings to 30% of the nameplate ratings before any voltage regulation can react to the change of voltage. If other PV systems are located within close proximity to the Project being studied, these systems may be included in the voltage flicker test. The percent difference in voltage readings at the Project’s POI, and at any point in the distribution circuit, shall be validated using the GE flicker table. If the cloud shading results in less than a 1.8% change in primary voltage at any point on the distribution circuit, the Project passes the voltage flicker test.

- GMP Protection Criteria:
 - Non-fault currents shall not exceed 83% of the phase pickup of an electronic recloser under the conditions of minimum load and 100% generation.
 - For reach, the pick-up level shall not be less than 3.0 for bolted LLL and LG faults.
- GMP Thermal Criteria:
 - The aggregate proposed and installed DER on the feeder under study, including the Project, with generation output at 100% and minimum load, shall not exceed:
 - 90% of a conductor's ampacity rating (both overhead and underground conductor);
 - 100% of a sectionalizing fuse's continuous rating;
 - 100% of a sectionalizer's continuous rating;
 - 100% of a switch's continuous rating;
 - 100% of a load tap changer's continuous rating;
 - 100% of a recloser's continuous rating; and
 - 100% of a regulator's continuous rating, without load bonus.
 - The aggregate proposed and installed DER on the feeder under study, including the Project, with generation output at 100% and *no load*, shall not exceed:
 - 100% of the power transformer's top nameplate on a per-winding basis.
- Further information on GMP assumptions and requirements can be found in the Green Mountain Power Interconnection Guidelines for Distributed Energy Resources at <https://greenmountainpower.com/wp-content/uploads/2017/01/Final-2021-DER-Guidelines-2-2021-03-19.pdf>

SECTION 2

Rule 5.505 (B) Criteria and Fast Track Review

Criteria that are not passed will be colored in red.

- 1) **The Interconnection Requester's proposed Generation Resource meets the applicable codes and standards of Section 5.510 of Vermont Public Utility Commission's Rule 5.500 or is certified equipment package under Section 5.511.**

The inverters proposed for this project are 10 Chint Power Systems CPS SCH275KTL-DO/US-800 are compliant with GMP required UL1741 and IEEE 1547 standards. If another type of inverter is substituted, GMP shall be made aware of this proposed change.

- 2) **The proposed interconnection point is not at transmission voltage (i.e. not over 23 kV line to line or 11.38 line to neutral).**

The Project proposes to interconnect to GMP's CH-G11 distribution circuit, which has a voltage level of 12.47/7.2 kV and a four-wire, grounded-wye line configuration. This distribution circuit is not a transmission line.

- 3) **For interconnection to a Radial Feeder, the aggregated generation, including the proposed Generation Resource, on the circuit will not exceed 15% of the line section annual peak load as most recently measured at the substation. A line section is that portion of a distribution system connected to a customer bounded by Automatic Disconnect Devices or the end of the distribution line.**

The CH-G11 circuit peak demand is approximately 2,795 kW. Including the proposed Project, there would be approximately 6,943 kW of existing and proposed DG on this circuit. $6,943 \text{ kW} / 2,795 \text{ kW} = 248.0\%$.

The Project fails this criterion.

- 4) **The aggregated generation, including the proposed Generation Resource, on a distribution circuit will not contribute more than 10% to the distribution circuit's maximum fault current at the point on the high voltage (primary) level nearest the proposed interconnection point.**

The maximum available fault current at the POI, without distributed generation, is calculated as 1,782 amps (three-phase fault). With all distributed generation on-line, the maximum fault current at the POI increases to 2,134 amps (three-phase fault). The aggregate generation contributes 19.75% of the circuit's maximum fault current at the POI.

The Project fails this criterion.

- 5) The aggregated generation, including the proposed Generation Resources, on a distribution circuit will not cause any distribution protective devices and equipment (including, but not limited to, substation breakers, fuse cutouts, and line reclosers), or customer equipment on the system to exceed 85% of the short-circuit interrupting capability; nor is the Generation Resource proposed for a circuit that already exceeds 85% of the short-circuit interrupting capability.

The maximum fault current contribution from the aggregate generation does not exceed 85% of the short-circuit interrupting capability of any existing protective device or equipment.

- 6) For interconnection of a proposed single-phase or effectively-grounded three-phase Generation Resource where the primary distribution System is three-phase, four-wire, the Generation Resource will be connected line-to-neutral. For interconnection of a proposed single-phase or three-phase Generation Resource where the primary distribution system is three-phase, three-wire, the Generation Resource will be connected line-to-line.

This circuit is a three phase, four wire multi-grounded neutral system, otherwise known as “grounded wye”. The proposed Project will be connected through a grounded wye-grounded wye transformer. This Project connection is considered as ineffectively grounded with three phase inverter based sources.

- Due to its size, the Project is required to install a PCC recloser.*
- GMP also requires the inverters used for this project to comply with the Inverter Source Requirement Document of ISO New England (ISO-NE SRD). As part of the ISO-NE SRD requirements, GMP requires the Project to enter “momentary cessation” for over voltage conditions while operating in the “Permissive Operation” mode (Table III: Inverters Voltage Ride-through Capability and Operational Requirements). GMP requires the inverters to enter “Permissive Operation with Momentary Cessation” with a Maximum Response of 0.1s. If the proposed inverters are not capable of this Maximum Response Time, a Category III inverter shall be used instead which can comply with this requirement (IEEE 2018 6.4.2 Table 16). Inverter responses to under voltages while operating in the Permissive Operation mode are specified in the ISO-NE SRD at footnotes a and b.*

- 7) Voltage drop due to starting the proposed generator is within acceptable limits, meaning that inrush current, due to starting the proposed Generation Resource up to once per hour, is not greater than 3% of the available fault current. Voltage drop due to starting the proposed Generation Resource more than once per hour meets a tighter inrush-current tolerance, to be determined by the Interconnecting Utility.

The test for voltage drop is discussed above in Section 1 under Modeling Assumptions. For cloud shading, the maximum voltage change at the Project’s POI is 1.2%, which is acceptable.

- 8) For any single Generation Resource, the available utility short circuit current at the Point of Interconnection divided by the rated output current of the Generation Resource is no less than:
- a) 50 for Generation Resource of less than 100 kW;
 - b) 40 for Generation Resources from 100 kW to less than 500 kW; and
 - c) 20 for Generation Resources equal to or greater than 500 kW.

The maximum available fault current at the POI is calculated as 2,134 amps three-phase. The rated output current of the Project is 127 amps. The ratio of fault current to Project output current is 16.87, which is less than the required 20 for generation resources equal to or greater than 500kW.

- 9) Aggregate generation, including the Generation Resource, on a circuit will not exceed 2 MVA in an area where there are known or posted transient stability limitations to generating units located in the general electrical vicinity (e.g. three or four busses from the point of interconnection).

GMP is not aware of transient stability limitations in this area.

- 10) No System Upgrades, in excess of limited preparation that do not necessitate a Facilities Study, are required to facilitate the interconnection of the Generation Resource.

This criterion cannot be determined by Section 2 alone. See the Supplemental Review (Section 3) and the Conclusion (Section 4).

- 11) For interconnection of the proposed Generation Resource to the load side of spot network protectors, the proposed Generation Resource utilizes inverter-based equipment and aggregate generation, including proposed Generation Resource, will not exceed the smaller of 5% of a spot network's maximum load or 50 kW. Synchronous generators cannot be connected to a secondary network.

There are no spot networks on the GMP system.

- 12) If the Generation Resource is to be connected on a shared, single-phase secondary, aggregate generation capacity on the shared secondary, including the proposed generation, will not exceed 20 kVA.

Not Applicable. The Project is three-phase.

- 13) If the Generation Resource is single-phased and is to be interconnected on a center tap neutral of a 240 volts service, its addition will not create an imbalance between the two side of the 240 volt service of more than 20% of the service transformer nameplate.

Not Applicable. The Project is three-phase.

SECTION 3

Supplemental Review

This section assesses whether failed criteria identified in Section 2 can be addressed, to ensure safe and reliable interconnection of the Project, using known solutions that would not require a System Impact Study. This supplemental review may also address potential issues that are not covered in the existing fast track criteria, such as islanding, transmission impacts, steady state voltages, and protection.

Fast Track Summary

The Project did not pass the following criteria:

Criterion 3: Temporary Over Voltage (TOV), Protection Device Loading & Coordination, Reverse Flow, Transmission, Voltage, Thermal Loading, Islanding, and Impact to other Utilities.

Criterion 4: Protection Device Loading & Coordination

Criterion 6: Effective Grounding, Temporary Over Voltage (TOV)

Criterion 8: Islanding, Protection Device Loading & Coordination, and Voltage

Criterion 10: System Upgrades, Facilities Study

Further analysis is described below.

Protection Device Loading & Coordination: Pass

This test considers whether the total generation beyond a protective device can cause enough current flow that would erroneously cause the protective device to operate. This test considers a worst-case scenario of no load with generation at 100%; if that screen fails, a less conservative scenario of *minimum* load with generation at 100% is then considered. The results are presented below:

- Station high-side fuse: The high-side fuse at the Chester substation has a rating of 150A at 46kV. GMP sets the continuous current limit through this breaker at 150/1.2 or 125 amps. Under the conditions described above, there would be a maximum current flow of 97 amps through this fuse.
- CH-G11 substation breaker: The CH-G11 circuit breaker is set at 480 amps per phase pick-up. GMP sets the continuous current limit through this breaker at 480/1.2 or 400 amps. Under the conditions described above, there would be a maximum current flow of 312 amps through this breaker.

The existing & new protective devices on the CH-G11 circuit were reviewed to ensure proper coordination with the additional generation. The addition of the Project does not result in mis-coordination.

Thermal Loading: Fail

This test considers whether current flow due to generation can result in thermal overloads on equipment including, but not necessarily limited to, overhead conductors, cables, switches, regulators, and, reactors. Refer to Section 1-Modeling Assumptions for GMP thermal criteria. After review, GMP found thermal overload issues resulting from this interconnection.

With 100% generation and incorporating minimum load, the following equipment is overloaded and must be upgraded:

- **Three-phase 1/0 (6/1)ACSR overhead conductor from L3 P80-81 to L3 P84, 206A limit (approximately 579 feet).**
 - This conductor must be upgraded to three-phase 477 15kV Poly Tree Wire.

Substation and Transmission Capacity: Pass

This test considers whether current flow due to generation can overload the substation transformer, high-side fusing (or breaker) or, the transmission line entering the substation. When all feeders connected to the station are considered, a total of 8,024 KW of reverse flow would occur if the load was at 0% while the generation was at 100%. The top nameplate rating of the substation transformer is 10.5 MVA. After review, GMP found no overloads.

System Voltages: Pass

Steady state voltage: Pass

This test considers whether there could be reverse power flow on any regulators, and if so, whether they are capable of proper regulation in the reverse direction. This test also considers whether there are any other steady state voltage issues (i.e. voltages that fall outside of the limits specified by ANSI C84.1)

- **Reverse flow controls:** Pass – The only regulators on the CH-G11 circuit between the Project and the substation transformer are the Chester substation regulators. At minimum load and maximum generation, there would be reverse flow through these regulators. The controls for these regulators are capable of, and have been set for, reverse flow.
- **Voltage levels:** Pass – In the conservative case of peak generation and minimum load, steady state voltages are found to be inside ANSI limits.
- **Voltage imbalance:** Pass – The imbalance in all sections of the three-phase line serving three-phase or two-phase load is less than 3% both before and after this Project.

Ground Fault Over Voltage (GFOV): Pass

- **GFOV on the distribution system:** Pass - The possibility of GFOV on the distribution system (DGFOV) is of concern when the minimum load to generation ratio is less than 2. After review, the minimum load to aggregate generation ratio on the circuit is less than 2.

DGFOV will be addressed by the required PCC recloser.

- **GFOV on the subtransmission:** Pass - The possibility of ground fault over voltage on the transmission system (TGFOV) is a concern when there is a reverse flow of power onto the transmission system that cannot be dampened during line-to-ground faults on the transmission. TGFOV can also occur with no reverse flow when the minimum load-to-generation ratio for the section of the transmission system at issue is less than 2. The minimum load-to-generation ratio on the 46kV subtransmission supply is less than 2. An existing direct transfer trip (DTT) protection scheme is in place from the Chester substation breaker to the upstream transmission breakers. Therefore the possibility of TGFOV has been mitigated.
- **GFOV beyond a stepdown:** Pass - There are no transformers, stepdown or otherwise, between the Project and the station bus excluding the Project's local GSU.

Flicker Voltage Fluctuation: Conditional Pass

- **Natural transients** (fast moving cloud cover): Pass - This test considers whether voltage fluctuation due to rapidly moving clouds is within limits. This issue was covered under Section 2, Criterion 7. Voltage fluctuation due to rapidly moving clouds is within limits.
- **Generator Reconnection:** Conditional Pass – Traditionally, inverter-based distributed generation is assumed to reconnect to a system, following the operation of a protective device that caused the generation to go off-line, five minutes after healthy grid voltage is detected. GMP is concerned, however, that simultaneous reconnection of substantial amounts of distributed generation can result in temporary high voltages and excessive voltage regulator operation. Given the large amount of distributed generation on this circuit, GMP requires that the Project reconnect at ten minutes following the detection of healthy voltage. This Project is also required to comply with the ISO-NE SRD for gradual ramp rate of 2% of maximum current output per second.
- **Generator Synchronization:** Pass – This generation connects to GMP via an inverter which complies with IEEE & UL standards.

Unintentional Islanding: Pass

GMP considers whether the proposed Project, along with other distributed energy resources (DER) on the Affected System, is capable of supporting an unintentional island. To test for the possibility of unintentional islanding, GMP employs the following test:²

- First, GMP ensures that the Project's inverters meet applicable standards for anti-islanding.

After review, GMP finds that the Project's inverters are compliant with GMP required UL1741 and IEEE 1547 standards

- Second, GMP considers the size of the Project, and for each line segment upstream of the Project, considers the aggregate amount of DER on that line segment, the percentage of this DER that is rotating machine or non-certified, and the line segment's minimum load.

After review, GMP finds that each line segment upstream of the Project shall be equipped with a reclose block protection strategy. The only line segment upstream of the Project is denoted by the CH-G11 breaker and the PCC recloser. The CH-G11 breaker is not presently equipped with reclose block. Thus, a reclose block strategy will need to be implemented on the CH-G11 breaker.

Monitoring and Control: Pass

Based on the Project's size, GMP requires the ability to monitor the Project's status and output. This requirement shall be met by the installation of a GMP PCC recloser. The Project will be responsible for the recurring monthly cost of the SCADA communications to the PCC recloser.

Impact to Other Utilities: Pass - There are no impacts to other utilities due to this Project.

² GMP recognizes that, even if a project passes its anti-islanding test, it is theoretically possible for an unintentional island to form. Specifically, an unintentional island could form in the very rare instance that: 1) a circuit switching device is opened in a *non-fault* situation; 2) at the moment of switching, downstream of this device, there is a near-perfect match between real power generation and load; and 3) at the moment of switching, downstream of this device, there is a near-perfect match between reactive power generation and load. GMP notes that from a worker and public safety perspective, this situation is analogous to that of a customer's back-up generator inadvertently feeding back onto a part of the distribution system that may otherwise be considered to be de-energized. As a result, and to maximize safety, GMP relies on its existing operational practices to protect the public and its workers. Among these is the practice that, at all times, lines are considered to be energized until a qualified GMP employee is on site to verify that the line has in fact been de-energized and is safe to be approached.

SECTION 4

Conclusion

The Project can move forward, without a System Impact Study. However, a Facilities Study will be required to develop the costs of the reclose block scheme(3[b]). The following measures must be completed prior to interconnection:

- 1) Construction of a three-phase line extension approximately 250 feet in length of 1/0 poly conductor including the installation of a three-phase 3000kVA 12.47/7.2kV primary & 800/462V secondary volt pad-mounted transformers provided by the Project, a primary metering package, and disconnect switch. The GMP facilities need to be accessible by GMP trucks and the exact location of the take-off pole and line extension poles to be determined by site visit with the Distribution Designer.
- 2) Installation of a Viper-S PCC recloser. The Project will be responsible for the recurring monthly cost of the SCADA communications to the PCC recloser.
- 3) The following protection upgrades are required:
 - a. Implementation of a live line reclose block protection scheme at the CH-G11 breaker relay.
- 4) The following upgrades to the primary system and Chester substation are required:
 - a. The existing conductor form L3 P80 to L3 P84 must be upgraded to three-phase 477ACSR poly line (approximately 579').
- 5) GMP requires that the inverters used for this project comply with the Inverter Source Requirement Document of ISO New England (ISO-NE SRD). As part of the ISO-NE SRD requirements, GMP requires the Project to enter "momentary cessation" for over voltage conditions while operating in the "Permissive Operation" mode (Table III: Inverters Voltage Ride-through Capability and Operational Requirements). GMP requires the inverters to enter "Permissive Operation with Momentary Cessation" with a Maximum Response of 0.1s. If the proposed inverters are not capable of this Maximum Response Time, a Category III inverter shall be used instead which can comply with this requirement (IEEE 2018 6.4.2 Table 16). Inverter responses to under voltages while operating in the Permissive Operation mode are specified in the ISO-NE SRD at footnotes a and b.
- 6) GMP requires the Project's inverters reconnect using a Soft-Start Ramp rate of 2% of maximum current output per second with a modified reconnection time of ten minutes.
- 7) The Project is required to execute a Project Notice to Proceed with the appropriate GMP distribution designer when the Project is physically ready for interconnection to GMP's system.
- 8) Approval of generation notification form with ISO-NE.

Upgrades not resulting from the Project but are required before interconnection (GMP or other project's responsibility):

1) None.

Note that at the time of this report, the longest lead-time material for the GMP portion of this Project is approximately eighty-four (84) weeks. Lead times for all materials required for this Project are subject to change based upon manufacturer availability and delivery times. GMP will order materials for this Project when the customer provides payment. GMP cannot guarantee the availability of materials out of its stock.