GENERATOR INTERCONNECTION
FEASIBILITY STUDY REPORT

for integration of the proposed

30 MW [redacted] SOLAR PROJECT
IPC PROJECT QUEUE #556

to the

IDAHO POWER COMPANY TRANSMISSION SYSTEM

for

[redacted]

REPORT v.0

September 3, 2019

Revision History

Date	Revision	Initials	Summary of Changes
9/03/2019	0	MDH	FeSR GI #556 – Original issue.

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1.0 Introduction

[redacted] has contracted with Idaho Power Company (IPC) to perform a Generator Interconnection Feasibility Study for the integration of the proposed 30 MW [redacted] Solar Project (the Project). The Project is to be located [redacted] in Grant County, Oregon (See Figure 1 Location of [redacted] Solar Project – GI #556 in Appendix B). The project latitude and longitude coordinates are approximately [redacted]. The Project is Generation Interconnect queue number 556 (GI #556).

The Project has applied to connect to the Idaho Power transmission system for an injection of 30 MW at a single Point of Interconnection (POI) at 138 kilovolts (kV). The POI is on IPC's [redacted] section of the [redacted] 138kV line approximately [redacted] miles from IPC's [redacted] station and approximately [redacted] miles from Oregon Trail Electric Cooperative's (OTEC's)/IPC's [redacted] station.

This report documents the basis for and the results of this feasibility study for the GI #556 Generation Interconnection Customer. The report describes the proposed project, the determination of project interconnection feasibility and estimated costs for integration of the Project to the Idaho Power System. This report satisfies the feasibility study requirements of the Idaho Power Tariff.

2.0 Summary

The feasibility of interconnecting the 30 MW [redacted] Solar Project to IPC's [redacted] section of the [redacted] 138kV line was evaluated. The POI evaluated is approximately located at [redacted].

The power flow analysis indicated that interconnecting the 30 MW [redacted] Solar Project to Idaho Power's [redacted] section of the [redacted] 138kV line is feasible.

The Project will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations. Therefore, GI #556 will be required to install a plant controller for managing the real and reactive power output of the 30 MW inverter array at the project POI. Also, the installation of phasor measurement unit devices (PMU's) at the POI and the maintenance costs associated with communication circuits needed to stream PMU data will be required to be provided to interconnect GI #556.

It is the generation project's responsibility to provide reactive power capability of the project to have a power factor operating range of at least 0.95 leading (absorbing) to at least 0.95 lagging (supplying) at the POI over the range of real power output (up to maximum output of the project.

A Transmission System Impact Study is required to determine if any additional network upgrades are required to integrate the Project into the IPC transmission system and to evaluate system impacts such as thermal, voltage, transient stability, and reactive margin. Generator interconnection service, either as an Energy Resource or a Network Resource, does not in any way convey any right to deliver electricity to any specific customer or point of delivery.

The total preliminary cost estimate to interconnect the 30 MW [redacted] Solar Project to the [redacted] section of the [redacted] 138kV line is $3,835,000, (See Table 1 Conceptual-Level Cost Estimate for GI #556) and includes the following tasks:

- New GI #556 138kV Generation Interconnection Station.
- New [redacted] 138kV Line Terminal.
- [redacted] 103A Open-Breaker Transfer Trip Scheme.

The cost estimate includes direct equipment and installation labor costs, indirect labor costs and general overheads. The estimate does include a contingency allowance. These are cost estimates only and final charges to the customer will be based on the actual construction costs incurred. It should be noted that the preliminary cost estimate of $3,835,000 does not include the cost of the customer's owned equipment to construct the solar generation site or required communication circuits.

Bonneville Power Administration (BPA) has proposed generation projects prior to the Project which have requested to be interconnected to BPA's [redacted] 115kV line and in the [redacted] area. For this feasibility study, a minimum of 115 MW of project generation was assumed to be interconnected to the BPA 115kV transmission system prior to the Project. The resolution of BPA's generation requests in this area has not been finalized and any forthcoming material changes will be incorporated into the Transmission System Impact Study if the Project chooses to proceed.

Idaho Power transmission system upgrades might be required for projects ahead in the queue of this project, GI #556. In the scenario that a project(s) in the queue prior to this project withdraws or falls out of the queue, the feasibility study for this project will need to be re-evaluated and potentially re-studied. This may result in required additional system upgrades for GI #556.

3.0 Scope of Interconnection Feasibility Study

The Interconnection Feasibility Study was done and prepared in accordance with Idaho Power Company Standard Generator Interconnection Procedures to provide a preliminary evaluation of the feasibility of the interconnection of the proposed generating project to the Idaho Power system. As listed in the Interconnection Feasibility Study agreement, the Interconnection Feasibility Study report provides the following information:

- preliminary identification of any circuit breaker short circuit capability limits exceeded because of the interconnection;
- preliminary identification of any thermal overload or voltage limit violations resulting from the interconnection; and
- preliminary description and non-binding estimated cost of facilities required to interconnect the Large Generating Facility to the IPC system and to address the identified short circuit and power flow issues.

All other proposed generation projects prior to the Project in IPC's and Bonneville Power Administration's (BPA's) Generator Interconnect queues were considered in this study. A

current list of IPC's projects can be found in the Generation Interconnection folder located on the Idaho Power web site at the link shown below:

http://www.oatioasis.com/ipco/index.html.

BPA's proposed generation projects considered in this study are addressed in the Section 5.0 Contingent Facilities.

4.0 Affected Parties

The Oregon Trail Electric Cooperative (OTEC) and Bonneville Power Administration (BPA) are affected parties to this generation interconnection request and will be provided copies of the Feasibility Study report.

5.0 Contingent Projects/Facilities

The ~263-mile transmission system/network which the Project requests to interconnect to consists of the following facilities:

[redacted] 138kV line (133.5 miles IPC/OTEC)
[redacted] 115kV (3.4 miles IPC)
[redacted] 138/115kV 48/64/80 MVA auto-transformer (IPC – upgraded fall of 2019)
[redacted] 115kV line (~113 miles BPA)
[redacted] (~13 miles BPA)

This transmission system/network is jointly owned by IPC, OTEC, and BPA with an interconnection tie-line between IPC and BPA at BPA's [redacted] 115kV station.

BPA's proposed generation projects prior to the Project which have requested to be interconnected to BPA's [redacted] 115kV line and in the [redacted] area that were considered in the Study:

G0520 (20 MW)
G0522 (20 MW)
G0525 (20 MW)
G0536 (20 MW)
G0537 (20 MW)
G0538 (20 MW)
G0592 (40 MW)

The sum of the projects (160 MW) requesting to interconnect with BPA exceeds the thermal capability of the [redacted] 115kV and [redacted] 115kV lines which will require upgrading ~126 miles of 115kV transmission line which for all practicality makes the G0592 40 MW project unfeasible. The first four projects have proceeded to construction with the first two to be completed by the end of 2019, the third by the end of 2020, and finally the fourth by the of 2021. However, the four projects will be restricted to the 75 MW of firm transmission service acquired/granted by BPA. So, for this feasibility study, a minimum of 115 MW of project generation was assumed to be interconnected to the BPA 115kV transmission system prior to the

Project. The resolution of BPA's generation requests in this area has not been finalized and any forthcoming material changes will be incorporated into the Transmission System Impact Study if the Project chooses to proceed.

BPA's contingent facilities beyond the initial four projects:

- Upgrade the [redacted] 115kV line to 100° C thermal capability
- For loss of BPA's [redacted] 115kV line, a generation tripping Remedial Action Scheme (RAS) to protect the [redacted] 138/115kV transformer from thermal overload, and the IPC/OTEC 138kV transmission system from voltage instability.

Idaho Power transmission system upgrades might be required for projects ahead in the queue of this project, GI #556. The system upgrades assigned to projects ahead of GI #556 will be modeled in this Feasibility Study and the Transmission System Impact Study for GI #556, if the project chooses to move forward. In the scenario that a project(s) in the queue prior to this project withdraws or falls out of the queue, the feasibility study for this project will need to be re-evaluated and potentially re-studied. This may result in required additional system upgrades for GI #556.

6.0 Description of Proposed Generating Project

The proposed [redacted] Solar Project, GI #556, consists of a single 30 MW photovoltaic solar plant which requested to be connected to IPC's [redacted] section of the [redacted] 138kV line at the approximate coordinate location of [redacted]. The Project's Commercial Operation Date (COD) is November 30, 2021.

The Project's supplied single line drawing shows the project using 272 125 kW/125 kVA CPS SCH125KTL-DO/US-600 inverters. Seventeen groups of sixteen inverters will be connected to 2.0 MVA transformers to step-up the voltage from 600 V to 34.5kV. The seventeen transformers will be connected to the GSU 34.5/138kV transformer with a 21/28/35 MVA capacity.

All generation in voltage regulation (reactive capability used to regulate 138kV bus voltage – supply/absorb reactive).

7.0 Description of Substation Facilities

The interconnection of GI #556, to the [redacted] 138kV line will require the installation of an additional 138kV circuit breaker to alleviate protective relaying issues. The [redacted] 138kV line is already a three-terminal line. It is Idaho Power's policy to not allow another tap on this line and create a four-terminal line due to technical protective relaying issues. From a transmission system perspective, it was determined the best location, for this additional 138kV sectionalizing breaker, would be to install it on the west-side of [redacted] looking toward [redacted]. Thus, breaking the existing [redacted] 138kV line into a [redacted] 138kV line and a [redacted] 138kV line. Loss of the [redacted] 138kV line leaves the [redacted] and GI # 556 stations connected to the Idaho Power's [redacted] station. Corollary, the loss of [redacted] line including the [redacted] load taps does not strand the [redacted] station on a ~ 200-mile radial line from [redacted].

At the proposed GI #556 POI, Idaho Power will construct a single 138kV breaker generation integration station tapping the [redacted] line section and creating the previously discussed [redacted] 138kV line.

8.0 Description of Transmission Facilities

The Project's impact on the Idaho-Northwest transmission path (WECC Path #14) and Brownlee East transmission path (WECC Path #55) were evaluated in this Generation Feasibility Study. The Idaho-Northwest transmission path was studied at both its West-to-East 1200 MW and East-to-West rated transfer capabilities. The Brownlee East transmission path was studied at its 1915 MW rated West-to-East transfer capability.

The Idaho-Northwest transmission path (WECC Path #14) is defined as the sum of the flows on the following five lines:

- Oxbow-Lolo 230kV
- Hells Canyon-Hurricane 230kV
- North Powder-La Grande 230kV
- Hines-Harney 115kV
- Hemingway-Summer Lake 500kV

The Brownlee East transmission path (WECC Path #55) is defined as the sum of the flows on the following seven lines:

- Brownlee-Boise Bench #1 230kV
- Brownlee-Boise Bench #2 230kV
- Brownlee-Boise Bench #3 230kV
- Brownlee-Horse Flat #4 230kV
- Brownlee-Ontario 230kV
- Oxbow-Starkey 138kV
- Quartz-Ontario 138kV

For this generation interconnection Feasibility Study, the flow on the Path 14 Idaho-Northwest transmission path was modeled at 1200 MW West-to-East and the Brownlee East transmission path was modeled at 1915 MW West-to-East. The paths were stressed to these specific levels to determine if the addition of the Project's 30 MW degraded the existing Brownlee East path's transfer capability.

And, a Path 14 Idaho-Northwest study was performed to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest West-to-East rating of 1200 MW.

In addition to the Path 55 Brownlee East and Path 14 Idaho-Northwest West-to-East transmission paths studies, a Path 14 East-to-West sensitivity study was performed to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest East-to-West rating of 2400 MW.

9.0 Description of Power Flow Cases

For this Generation Interconnection Feasibility Study, four sets of power flow cases (without and with the Project) were used to evaluate the potential impacts due to the 30 MW [redacted] Solar Project, GI #556.

For the Path 14 Idaho-Northwest West-to-East 1200 MW transfer path rating impact study due to the addition of the Project, the WECC 2019 Heavy Summer case was chosen as the power flow base case. These cases were modified to stress the Idaho-Northwest transmission path West-to-East flows to 1200 MW simultaneous with other transmission paths in the Northwest at or near their respective maximum transfer capacity ratings to determine the potential impact due to the addition of the 30 MW Project.

The second set of cases were a modified set of the Path 14 Idaho-Northwest West-to-East transfer path rating impact study. These cases were modified to represent spring (late March to early May) load condition in the local area (between [redacted] to [redacted]) prior to air condition and irrigation load. These cases were used to evaluate the impact of the 30 MW Project in the local area system during minimum load shoulder months conditions (non-summer and non-winter).

For the third set of cases the WECC 2019 Heavy Summer case was again chosen as the power flow base case for the Brownlee East 1915 MW transfer path rating impact study. Path 14 Idaho-Northwest transmission path was modeled at 1200 MW West-to-East and the Brownlee East transmission path was modeled at 1915 MW West-to-East. The paths were stressed to these specific levels to determine if the addition of the Project's 30 MW degraded the existing Brownlee East path's transfer capability.

The fourth and final set of cases used an older Idaho-Northwest East-to-West 2400 MW power flow study case, which was developed from the WECC 2015 Light Summer base case, to determine the Project's 30 MW potential impact on Path 14 Idaho-Northwest East-to-West rating of 2400 MW.

9.1 Power Flow Analysis Results

Results from the Path 14 Idaho-Northwest West-to-East 1200 MW "Spring" transfer path rating impact study case indicate the addition of the GI #556 project will result in potentially unacceptable performance on the BPA's 115kV transmission system.

1. The [redacted] 138kV Bus Differential (Open-ends [redacted] 138kV line – NERC TPL-001-4 P2-1)
    a. This contingency results in a post-transient voltage dip of 8.52% (0.914 p.u. absolute voltage) at BPA's [redacted] 115kV load bus.

With light spring loads (≤ 20 MW) modeled at the [redacted] and [redacted] load busses, open-ending the [redacted] 138kV line at [redacted] without tripping GI_556 generation is approaching voltage instability in the BPA 115kV transmission system. Even though the condition resulted in a stable operating point when tested with 5% greater generation in the area ([redacted] 115kV load bus voltage dip 10.0% (0.897 p.u. absolute voltage)), it is an operating point which would be unacceptable to operate at for any length of time. Therefore, it is recommended a [redacted] 103A (breaker at [redacted] on the [redacted] 138kV line) Open-Breaker Transfer Trip scheme be implemented to trip the line and subsequently GI #556 generation to move to a more stable operating point in a timely manner.

And, given this result, GI #556 generation may have to be curtailed to 0 MW even if the [redacted] section is restored after the loss of the [redacted] 138kV because of the lack

of remaining capacity on the BPA 115kV transmission system to wheel the generation back to the Idaho Power transmission system.

10.0 Short Circuit Study Results

The fault duty at the approximate POI location (with the Project modeled) is as follows.

Single-Line-to-Ground Fault Duty = 1544 Amps

Line-to-Line Fault Duty = 1542 Amps

Three-Phase Fault Duty = 1779 Amps

The fault current contribution from the 30 MW PV facility does not exceed any circuit breaker rating.

The 138/34.5kV GSU transformer does not meet Idaho Power's transmission interconnection grounding requirements for system protection which requires a ground source on the high-side of the transformer. This can be typically achieved with an auto-transformer with a delta tertiary which is a source of ground current, (other configurations can and do exist). Refer to Appendix A, Section 3, for additional grounding requirements.

11.0 Description of Required Facility Upgrades

The Project will be required to provide a plant controller that will operate the inverter system in Volt/VAr control mode. This is to regulate voltage according to a voltage schedule that will be provided by Idaho Power.

The following upgrades will be required to IPC-owned facilities to facilitate the interconnection of GI #556:

- GI #556 138kV Transmission Line Tap (138kV Line Tap, and two 138kV Air-Break Switches with Interrupters)
- GI #556 Generation Interconnection Station (Single 138kV Breaker/Line Terminal)
- [redacted] 138kV Line Terminal (Additional 138kV Sectionalizing Breaker/Line Terminals)
- [redacted] 103A Open-Breaker Transfer Trip Scheme

See the conceptual-level cost estimate in Table 1.

Table 1 Conceptual-Level Cost Estimate for GI #556

GI #556 [redacted] 30 MW Solar Project **Network Resource Generation Interconnection Facilities**	
	Cost
GI #556 138kV Transmission Line Tap	$240,000
GI #556 Generation Interconnection Station	$1,315,000
[redacted] 138kV Line Terminal	$1,020,000

[redacted] 103A Open-Breaker Transfer Trip Scheme	$330,000
Subtotal	**$2,905,000**
Contingency (~20.0%) (1)	$580,000
Subtotal	**$3,485,000**
Overheads (~10.0%) (2)	$350,000
Network Resource Generation Interconnection Facilities Total Conceptual-level Cost Estimate in 2019 dollars (3)	**$3,835,000**

(1) Contingency is added to cover the unforeseen costs in the estimate. These costs can include unidentified design components, material cost increases, labor estimate shortfalls, etc.
(2) Overhead costs cover the indirect costs associated with the Project.
(3) This cost estimate includes direct equipment, material, labor, and overheads as shown.

- Note that these estimates do not include the cost of the customer's equipment/facilities or required communication circuits for SCADA, PMU, and metering.
- Note that the overhead rates are subject to change during the year.
- These are estimated costs only and final charges to the customer will be based on the actual construction costs incurred.
- These are non-binding conceptual level cost estimates that will be further refined upon the request and completion of Transmission Facility Study.

12.0 Description of Operating Requirements

It is the generation project's responsibility to provide reactive power capability of the project to have a power factor operating range of at least 0.95 leading (absorbing) to at least 0.95 lagging (supplying) at the POI over the range of real power output (up to maximum output of the project). Assuming inverters with a power factor operating range of 0.9 lagging (supplying) at maximum output, the 0.95 lagging (supplying) reactive power capability at the POI cannot be achieved without additional shunt reactive support. The 7 MVAr 34.5kV shunt capacitor indicated on the Project's supplied single line drawing will be more than sufficient to make-up the reactive power deficiency.

Identification of any additional equipment required at the plant to meet Idaho Power reactive power capability interconnection requirements will be provided in the Transmission System Impact Study if the generation interconnection customer chooses to move to the next study phase of the interconnection process.

The inverter(s) will be required to have the UL 1741SA certification prior to the installation and be approved by Idaho Power cybersecurity group.

The Project will be required to control voltage in accordance with a voltage schedule as provided by Idaho Power Grid Operations. Therefore, GI #556 will be required to install a plant controller for managing the real and reactive power output of the 30 MW inverter array at the project POI.

Voltage flicker at startup and during operation will be limited to less than 5% as measured at the POI. The allowable voltage flicker limit is further reduced during operation due to multiple voltage fluctuations per hour or minute, per Idaho Power's T&D Advisory Information Manual.

The Project is required to comply with the applicable voltage fluctuation limits found in IEEE Standard 1453-2004 *IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems.*

The project is required to comply with the applicable Voltage and Current Distortion Limits found in IEEE Standard 519-2014 *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.*

Installation of phasor measurement unit devices at the POI and maintenance costs associated with communication circuits needed to stream PMU data will also be required to be provided to interconnect GI #556. The specific costs associated with the IPC requirements for interconnection customers with aggregate facilities larger than 20 MW to provide PMU data to IPC will be identified in the Facility Study should the generation interconnection customer choose to proceed to that phase of the interconnection process.

Besides the previously mentioned potential Project generation curtailment for the forced/planned outages of the [redacted] 138kV line section, the Project will be subjected to curtailments for planned outages in Idaho Power's transmission system beyond the [redacted] 230/138kV station. The [redacted] 230/138kV station is sourced/connected to the Idaho Power transmission system via the [redacted] 230kV line (~80 miles) / [redacted] 230/138kV transformer and the [redacted] 138kV line (~70 miles). When a line segment/transformer of one of these facilities is planned/forced out-of-service, the loss of the other facility will strand too much generation toward [redacted], Oregon resulting in voltage instability. Thus, necessitating pre-contingency generation curtailment in the [redacted] area, including GI #556 Project, after forced outages and before planned outages.

Additional operating requirements for the Project may be identified in the Transmission System Impact Study when it is performed.

13.0 Conclusion

The requested interconnection of the [redacted] Solar Project, GI #556, to Idaho Power's [redacted] section of the [redacted] 138kV line was studied.

The results of this study work confirm that it is feasible to interconnect the 30 MW [redacted] Solar Project, GI #556, to the Idaho Power transmission system with the identified Network Resource Generation Interconnection Facilities.

A Transmission System Impact Study is required to determine the specific transmission network upgrades required to integrate the project as a Network Resource and to evaluate the system impacts such as thermal overload, voltage, transient stability, and reactive margin.

All generation projects in the area ahead of the Project in IPC's/BPA's generation interconnection queue and their associated transmission system improvements were modeled in a preliminary power flow analysis to evaluate the feasibility of interconnecting GI #556. The results and conclusions of this feasibility study are based on the realization of these projects in the unique queue/project order.

The estimated cost to interconnect GI #556 to the IPC system at the 138kV point of interconnection considered in this study is approximately $3,835,000.

Generator interconnection service, either as an Energy Resource or a Network Resource, does not in any way convey any right to deliver electricity to any specific customer or point of delivery. Transmission requirements to integrate the Project will be determined during the Transmission System Impact Study phase of the generator interconnection process.

APPENDIX A

A-1.0 Method of Study

The Feasibility Study plan inserts the Project up to the maximum requested injection into the selected Western Electricity Coordinating Council (WECC) power flow case and then, using Power World Simulator or GE's Positive Sequence Load Flow (PSLF) analysis tool, examines the impacts of the new resource on Idaho Power's transmission system (lines, transformers, etc.) within the study area under various operating and outage scenarios. The WECC and Idaho Power reliability criteria and Idaho Power operating procedures were used to determine the acceptability of the configurations considered. The WECC case is a recent case modified to simulate stressed but reasonable pre-contingency energy transfers utilizing the IPC system. For distribution feeder analysis, Idaho Power utilizes DNV·GL's Synergi Electric software and EPRI's OpenDSS software.

A-2.0 Acceptability Criteria

The following acceptability criteria were used in the power flow analysis to determine under which system configuration modifications may be required:

The continuous rating of equipment is assumed to be the normal thermal rating of the equipment. This rating will be as determined by the manufacturer of the equipment or as determined by Idaho Power. Less than or equal to 100% of continuous rating is acceptable.

Idaho Power's Voltage Operating Guidelines were used to determine voltage requirements on the system. These states, in part, that distribution voltages, under normal operating conditions, are to be maintained within plus or minus 5% (0.05 per unit) of nominal everywhere on the feeder. Therefore, voltages greater than or equal to 0.95 pu voltage and less than or equal to 1.05 pu voltage are acceptable.

Voltage flicker during starting or stopping the generator is limited to 5% as measured at the point of interconnection, per Idaho Power's T&D Advisory Information Manual.

Idaho Power's Reliability Criteria for System Planning was used to determine proper transmission system operation.

All customer generation must meet IEEE 519 and ANSI C84.1 Standards.

All other applicable national and Idaho Power standards and prudent utility practices were used to determine the acceptability of the configurations considered.

The stable operation of the system requires an adequate supply of volt-amperes reactive (VAr or VArs) to maintain a stable voltage profile under both steady-state and dynamic system conditions. An inadequate supply of VArs will result in voltage decay or even collapse under the worst conditions.

Equipment/line/path ratings used will be those that are in use at the time of the study or that are represented by IPC upgrade projects that are either currently under construction or whose budgets have been approved for construction in the near future. All other potential future ratings

are outside the scope of this study. Future transmission changes may, however, affect current facility ratings used in the study.

A-3.0 Grounding Guidance

IPC requires interconnected transformers on the distribution system to limit their ground fault current to 20 amps at the Point of Interconnection.

A-4.0 Electrical System Protection Guidance

IPC requires electrical system protection per Facility Connection Requirements found on the Idaho Power Web site,

https://docs.idahopower.com/pdfs/BusinessToBusiness/FacConnReq.pdf

A-5.0 WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Requirements

IPC requires frequency operational limits to adhere to WECC Under-frequency and Over-frequency Limits per the WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Requirements available upon request.

APPENDIX B

B-1.0 [redacted] Solar Project GI #556 Site Location

REDACTED

Figure 1 Location of [redacted] Solar Project – GI #556