Inverter Based Resource (IBR) Technical Data Sheet

Facility Name: _____ **Queue # (if known):** _____

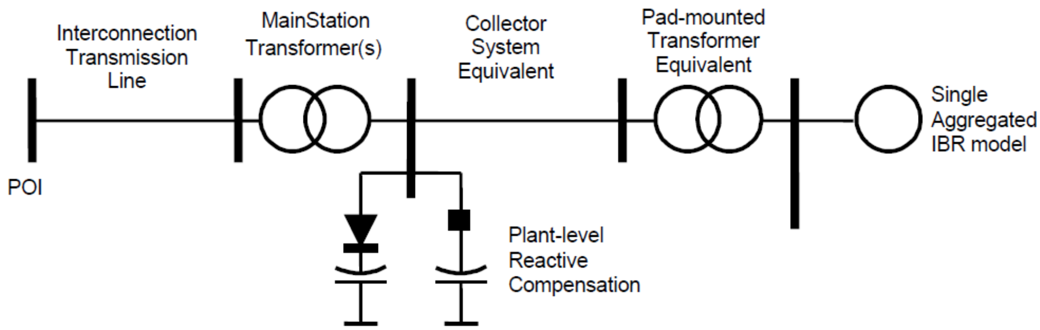
Provide a separate data sheet for each type of IBR and each type of transformer
Fill in data as appropriate according to the type of IBR. Where Not Applicable write NA

1. **Requested Net MW Injection at the POI:** _____ MW

   Gross Inverter Nameplate Capability: _____ MVA
   Station Service Load: _____ MW _____ Mvar

   Additional Information for Storage (For DC-connected batteries, include the following data on the solar inverter data sheet. For AC-connected batteries, complete a separate data sheet.)
   MW Rating of Storage: _____ MW for Time: _____ Hours
   Gross Energy Rating: _____ MW-HR
   Maximum State of Charge: _____ pu
   Minimum State of Charge: _____ pu

2. **Simplified One-Line Diagram.** This should be similar to the Figure below. If different, mark the differences on the diagram below or provide a new diagram.



3. **Interconnection Tie Line.**

   a) Point of Interconnection (substation or line name): _____

   b) Line voltage: _____ kV, line rating at 95°F (35°C) ambient: _____ MVA, line length: _____ Miles/Feet

   c) R_1 = _____ ohm or _____ pu on 100 MVA and line kV base (positive sequence)

   d) X_1 = _____ ohm or _____ pu on 100 MVA and line kV base (positive sequence)

   e) B_1 = _____ μF or _____ pu on 100 MVA and line kV base (positive sequence)

   f) R_0 = _____ ohm or _____ pu on 100 MVA and line kV base (zero sequence)

   g) X_0 = _____ ohm or _____ pu on 100 MVA and line kV base (zero sequence)

h) B_0 = _____ μF or _____ pu on 100 MVA and line kV base (zero sequence)

4. **Main Transformer.** Number of main transformers: _____

Two-Winding Main Transformer Data (as applicable):

a) Rating (ONAN/ONAF/ONAF): _____ / _____ / _____ MVA

b) Nominal Voltage for each winding (High/Low): _____ / _____ kV

c) Winding Connections (High/Low): [Delta or Wye] / [Delta or Wye]

d) Available tap positions: _____ / _____ / _____ / _____ / _____ kV **or** _____ % _____ # of taps.

e) Positive sequence impedance Z_1: _____ %, _____ X/R on _______ MVA base.

f) Zero sequence impedance Z_0: _____ %, _____ X/R on _______ MVA base.

g) For pad-mounted transformer, construction: 3 / 4 / 5 -legged

Three-Winding Main Transformer Data (as applicable)

h) Connection and winding (please attach diagram and mark to reference this form).

	H Winding Data	**X Winding Data**	**Y Winding Data**
Full load ratings (i.e. ONAN/ONAF/ONAF)	_____/_____/_____ MVA	_____/_____/_____ MVA	_____/_____/_____ MVA
Rated voltage base	_____ kV Delta or Wye connected	_____ kV Delta or Wye connected	_____ kV Delta or Wye connected
Tap positions available	______/ ______/ ______/ ______/ _____ kV	______/ ______/ ______/ ______/ _____ kV	______/ ______/ ______/ ______/ _____ kV
Present Tap Setting (if applicable)	_____ kV	_____ kV	_____ kV
Neutral solidly grounded? (or) Neutral Grounding Resistor (if applicable)	_____ _____ Ohms	_____ _____ Ohms	_____ _____ Ohms
BIL rating	_____ kV	_____ kV	_____ kV

Three-Winding Main Transformer Impedance Data (as applicable)

	H-X Winding Data	**H-Y Winding Data**	**X-Y Winding Data**
Transformer base for impedances provided	_____ MVA	_____ MVA	_____ MVA
Positive sequence impedance Z_1	_____ % _____ X/R	_____ % _____ X/R	_____ % _____ X/R
Zero sequence impedance Z_0	_____ % _____ X/R	_____ % _____ X/R	_____ % _____ X/R

5. **Collector System Equivalent Model**. (Calculated as per "WECC Guide for Representation of Photovoltaic Systems in Large-Scale Load Flow Simulations", January 2011)

a) Collector system one-line diagram attached: ☐

b) Collector system voltage = _____ kV

c) Collector system equivalent impedance:

i) R_1 = _____ ohm or _____ pu on 100 MVA and collector kV base (positive sequence)

ii) X_1 = _____ ohm or _____ pu on 100 MVA and collector kV base (positive sequence)

iii) C_1 = _____ μF or B_1 = _____ pu on 100 MVA and collector kV base (positive sequence)

iv) R_0 = _____ ohm or _____ pu on 100 MVA and collector kV base (zero sequence)

v) X_0 = _____ ohm or _____ pu on 100 MVA and collector kV base (zero sequence)

vi) C_0 = _____ μF or B_0 = _____ pu on 100 MVA and collector kV base (zero sequence)

d) Spreadsheet of individual, detailed cable impedances attached: ☐

6. **Inverter Step-Up Transformers.**

a) Number of inverter step-up transformers: ______ Rating: _____/_____/_____ MVA

Two-Winding Inverter Step-Up Transformer Data (as applicable):

b) Nominal Voltage for each winding (High/Low): _____ / _____ kV

c) Winding Connections: High: Delta or Wye / Low: Delta or Wye

d) Available taps: _____ / _____ / _____ / _____ / _____ kV **or** _____ % _____ # of taps.

e) Positive sequence impedance (Z_1) _____ %, _____ X/R on _______ MVA base.

f) Zero sequence impedance (Z_0) _____ %, _____ X/R on _______ MVA base.

Three-Winding Inverter Step-Up Transformer Data (as applicable)

g) Connection and winding (attach diagram and mark to reference this form).

	H Winding Data	**X Winding Data**	**Y Winding Data**
Full load ratings (i.e. ONAN/ONAF/ONAF)	_____/_____/_____ MVA	_____/_____/_____ MVA	_____/_____/_____ MVA
Rated voltage base	_____ kV Delta or Wye connected	_____ kV Delta or Wye connected	_____ kV Delta or Wye connected
Tap positions available	______/ ______/ ______/ ______/ _____ kV	______/ ______/ ______/ ______/ _____ kV	______/ ______/ ______/ ______/ _____ kV
Present Tap Setting (if applicable)	_____ kV	_____ kV	_____ kV
Neutral solidly grounded? (or) Neutral Grounding Resistor (if applicable)	_____ _____ Ohms	_____ _____ Ohms	_____ _____ Ohms
BIL rating	_____ kV	_____ kV	_____ kV

Three-Winding Inverter Step-Up Transformer Impedance Data (as applicable)

	H-X Winding Data	**H-Y Winding Data**	**X-Y Winding Data**
Transformer base for impedances provided	_____ MVA	_____ MVA	_____ MVA
Positive sequence impedance Z_1	_____ % _____ X/R	_____ % _____ X/R	_____ % _____ X/R
Zero sequence impedance Z_0	_____ % _____ X/R	_____ % _____ X/R	_____ % _____ X/R

7. **Inverter and IBR Data.**

a) Number of Inverters: _____

b) Inverter Capability

i) at 95°F (35°C): _____ kW/ _____ kVA

ii) at 113°F (45°C): _____ kW/ _____ kVA

c) Inverter Temperature Derating Curve attached: ____ ☐

d) Inverter Power Factor: _____ Leading _____ Lagging

e) IBR kW vs kvar capability curve

i) at 95°F (35°C) attached: ☐

ii) at 113°F (45°C) attached: ☐

f) Inverter Manufacturer and Model #: _____

g) IBR Module (e.g. solar panel or battery) Manufacturer and Model #: _____

h) Provide with this form appropriate verified dynamic models for the IBR. Include a power plant control model that provides volt/var control and active power/frequency control functions, in a Siemens/PTI PSS/E format. Models are expected to represent inverter, plant level controllers and any dynamic reactive resources as they are implemented in the real controls. Power plant controller models must be able to accept external reference values. If multiple IBR types are controlled by a common controller, this functionality must be included in the plant control model. All component models used should be properly integrated with other associated models in the plant model, including any third-party models such that they can send/receive ordered commands as applicable. All models shall be representations of the plant and parameterized to represent known site-specific controls, settings, and protections[1]. Provide BOTH user-written models[2] AND standard library "generic" models[3] (recommended REGCA1, REECA1, REECC1, REECDU1, REPCA1, REPCCU, REPCDU, VTGTPAT and FRQTPAT or similar as requested by Transmission Owner-TO). All the associated files for dynamic modeling should be in PSS/E version 34 and 35 formats.

In addition, the models shall:

[1] The default parameters listed in the model software manuals and provided in an initial model package by equipment vendor are typically provided only as a starting point to prevent model initialization issues. Those parameters are not suitable replacements for site-specific parameters. While finalized plant settings are not available during early stages of the interconnection process, the models should be parameterized with control modes and parameters that are as reflective of the intended final design as possible. Model submitters should utilize Duke Energy's IBR interconnection requirements and ensure appropriate parameters are reflected in the model to the best of their ability

[2] Also referred to as "user-defined model (UDM)," "user-written model" is used in this document for uniformity. A user-written model is any set of programming code created by equipment manufacturers or developers that captures the latest features of controllers that are mainly software-based and represent the entities' control strategies but does not necessarily correspond to any particular generic library model

[3] The term "generic" model is used to describe the industry approved collection of power system component models and are typically available as standard-library models in commercial simulation platforms like PSS/E. Limitations of these models, the model structure, user-selectable options, requirements for scaling the plant size, and representation of protection settings may exist since they are typically not designed specifically for a particular equipment manufacturer

- Include a single DYR file for each model type submission (generic AND user-written) that includes dynamic model records for each control type at a site (inverter, power plant controller, etc.). For battery energy storage sites, separate DYR files could be submitted for charging and discharging modes.

- Include a sample implementation test case. For example: aggregated generator model, aggregated generator transformer, equivalent collector branch, main step-up transformers, tie line, power plant controller, and any other static or dynamic reactive resources. A test case can use a single machine infinite bus representation of the system and must be provided for direct application of "generic" and user-written model file submissions.

- Provide control functions that exhibit appropriate dynamic response compliant with utility requirements including volt/var control, active power/frequency control and ride-through functions.

- Allow the user to determine the allocation of the bus number and machine IDs without restriction.

- Include compiled dynamic linked library (.dll) files for PSS/E version 34 & 35 such that no additional compiling is required for user-written models.

- Include documentation such as user manuals with description of model characteristics, control modes block diagrams, values, description for all model parameters and a list of all state variables.

- Include a user manual to describe procedures and considerations for integrating the model in dynamic simulations, including steady state representation and limitations for model adequacy and usability in the software.

Check here to indicate all required files are attached: ☐

i) Provide with this form appropriate Electromagnetic Transient (EMT) models for the IBR, in a Manitoba Hydro PSCAD format. All EMT models are expected be accurate representations of known site-specific controls and protections of the interconnecting facility and comprise of validated equipment EMT models. EMT models must have usability, accuracy, efficiency features in "Duke Energy Electromagnetic Transient Modeling Requirements" checklist found on the respective OASIS sites.

Check here to indicate all required files are attached: ☐

8. **Plant Reactive Power Compensation** (beyond the inverters' built-in reactive capability)**.**

a) Type of reactive compensation device(s): __________

b) Individual fixed shunt reactive device type: _____

- Number and size of each: _____×_____ MVA

c) Dynamic reactive control device (e.g., SVC, STATCOM): _____

d) Control range: _____ Mvar (lead) to _____ Mvar (lag)

e) Control mode (e.g., voltage, power factor, reactive power): _____

f) Regulation point: _____

g) Describe the overall reactive power control strategy: _____

h) Provide with this form the dynamic modeling data in a Siemens/PTI PSS/E standard model. If a user-written model is submitted in place of a generic model, it must include the model characteristics, including block diagrams, values and names for all model parameters, and a list of all state variables. All of the associated files for dynamic modeling should be in the PSS/E version requested by TO and must be shareable on an interconnection-wide basis to support use in the interconnection-wide cases.[4] Check here to indicate all required files are attached: _____

9. **Short Circuit Contribution of the Facility at the Point of Interconnection.**

a) Maximum Three Phase Fault Current: _____ Amps and Duration: _____

b) Maximum Single Line to Ground Fault* Current: _____ Amps and Duration: _____

Model and parameter data required for short-circuit analysis is specific to each PV inverter make and model. All data to be provided in per-unit ohms, on the equivalent inverter MVA base.

- Inverter Equivalent MVA Base: _____ MVA
- Short-Circuit Equivalent Pos. Seq. Resistance (R1), valid for initial 4 to 6 cycles: _____ pu.
- Short-Circuit Equivalent Pos. Seq. Reactance (XL1), valid for initial 4 to 6 cycles: _____ pu.
- Short-Circuit Equivalent Neg. Seq. Resistance (R2), valid for initial 4 to 6 cycles: _____ pu.
- Short-Circuit Equivalent Neg. Seq. Reactance (XL2), valid for initial 4 to 6 cycles: _____ pu.
- Short-Circuit Equivalent Zero Seq. Resistance (R0), valid for initial 4 to 6 cycles: _____ pu.
- Short-Circuit Equivalent Zero Seq. Reactance (XL0), valid for initial 4 to 6 cycles: _____ pu.
- Special notes regarding short-circuit modeling assumptions:

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* Single Line to Ground Fault at the Point of Interconnection with ties to utility at the POI ope

[4] As required by NERC Reliability Standard MOD-32-1.