

ERO Enterprise CMEP Practice Guide:

Application of the Bulk Electric System Definition to Battery Energy Storage Systems and Hybrid Resources

Version 1: February 2, 2021

Background

In support of successful implementation of and compliance with the North American Electric Reliability Corporation (NERC) Reliability Standards, the Electric Reliability Organization (ERO) Enterprise¹ adopted the Compliance Guidance Policy.² The Compliance Guidance Policy outlines the purpose, development, use, and maintenance of guidance for implementing Reliability Standards. According to the Compliance Guidance Policy, Compliance Guidance includes two types of guidance – Implementation Guidance and Compliance Monitoring and Enforcement Program (CMEP) Practice Guides.³

Purpose

The resource mix across North America is being transformed by the proliferation of installed renewable and inverter-based resources and interconnection queues filled with battery energy storage systems (BESS), solar photovoltaic (PV) systems, wind farms, and various combinations of these resources (i.e., hybrid power plants).

The purpose of this CMEP Practice Guide is to provide guidance to ERO Enterprise staff with respect to the consistent application of the BES Definition to BESS and hybrid resources, as well as to provide associated guidance related to the NERC Registration requirements for the owners and operators of these resources.

Application of the BES Definition to BESS and Hybrid Resources

Hybrid resources are commonly understood in the industry as follows:

- Hybrid resources are a combination of different resource technologies that are either operated together as a single resource or operated as individual (or separate) resources.⁴

As described below, whether the resources are operated together as a single resource or operated as individual resources is not a factor in the application of the BES Definition. In particular, this practice guide addresses ERO Enterprise application of the BES Definition⁵ to BESS and hybrid resources as a generating resource(s).

¹ The ERO Enterprise consists of NERC and the six Regional Entities.

² The ERO Enterprise Compliance Guidance Policy is located on the NERC website at:

http://www.nerc.com/pa/comp/Resources/ResourcesDL/Compliance_Guidance_Policy_FINAL_Board_Accepted_Nov_5_2015.pdf

³ Implementation Guidance provides a means for Registered Entities to develop examples or approaches to illustrate how Registered Entities could comply with a standard that are vetted by industry and endorsed by the ERO Enterprise. CMEP Practice Guides differ from Implementation Guidance in that they address how ERO Enterprise CMEP staff executes compliance monitoring and enforcement activities, rather than examples of how to implement the standard.

⁴ Hybrid resources whose resources are operated as individual (or separate) resources can also be referred to as co-located resources.

⁵ <https://www.nerc.com/pa/RAPA/Pages/BES.aspx>

The BES Definition includes a bright line criteria for what constitutes a BES Element with a set of Inclusions and Exclusions. Inclusion I4 establishes criteria for what constitutes dispersed power producing resources within the scope of the BES Definition as:

“resources that aggregate to a total capacity greater than 75 MVA (gross nameplate rating), and that are connected through a system designed primarily for delivering such capacity to a common point of connection at a voltage of 100 kV or above. Thus the facilities designated as BES are:

a) the individual resources, and

b) the system designed primarily for delivering capacity from the point where those resources aggregate to greater than 75 MVA to a common point of connection at a voltage of 100 kV or above.”

The BES Definition Reference Document⁶ provides the following guidance on which resources are applicable to Inclusion I4: *“Dispersed power producing resources are small-scale power generation technologies that use a system designed primarily for aggregating capacity providing an alternative to, or an enhancement of, the traditional electric power system. Examples could include, but are not limited to: solar, geothermal, energy storage, flywheels, wind, micro-turbines, and fuel cells.”* This highlights that Inclusion I4 applies to inverter-based resources such as BESS and solar PV, as well as wind resources (which may or may not be inverter-based) connected at a common point of connection at a voltage of 100 kV or above. Further, Inclusion I4 applies whether only one type of dispersed power producing resource is connected to a common point of connection, or whether a facility in question is considered a hybrid resource comprised of a combination of technologies.

Hybrid resources may also include other combinations of technologies such as dispersed power producing resources and synchronous generating resources. Inclusion I2 establishes the criteria for synchronous generating resources within the BES Definition as:

“generating resource(s) including the generator terminals through the high-side of the step-up transformer(s) connected at a voltage of 100 kV or above with:

a) Gross individual nameplate rating greater than 20 MVA. Or,

b) Gross plant/facility aggregate nameplate rating greater than 75 MVA.”

The BES Definition Reference Document provides the following additional guidance: *“Inclusion I2 provides for the inclusion of the Real Power resources that can generally be categorized as large-scale power generation resources that utilize a variety of conventional fuel sources/supplies (e.g., coal, natural gas, nuclear) as well as non-conventional fuel sources/supplies (e.g., biomass, wood pulp/byproducts, agricultural byproducts).”*

⁶ https://www.nerc.com/pa/RAPA/BES%20DL/bes_phase2_reference_document_20140325_final_clean.pdf

When considering application of the BES Definition to hybrid plants that include synchronous resources (Inclusion I2) and dispersed power resources (Inclusion I4), the BES Definition threshold of 75 MVA is the same in both Inclusions. In addition, the language “*gross plant/facility aggregate nameplate rating greater than 75 MVA*” of Inclusion I2 and the similar “*resources that aggregate to a total capacity greater than 75 MVA (gross nameplate rating)*” of Inclusion I4 both express the concepts of aggregating generation at a plant/facility and common point of connection to determine BES threshold applicability.

Accordingly, ERO Enterprise staff should ensure an aggregate of the gross nameplate ratings of all resources at the facility was used to determine the total nameplate capacity of the hybrid resource. If the total nameplate capacity exceeds 75 MVA, including all of the synchronous resources and dispersed power resources, then all the resources at the facility are BES resources.

ERO Enterprise staff shall consider the following key points when evaluating BESS and hybrid resources:

- BES resources are generally connected at a common point of connection of 100 kV or above
- Gross nameplate rating refers to the apparent power rating (MVA)
- In the determination of aggregate gross nameplate rating:
 - The apparent power rating of the inverter(s) should be used for inverter-based resources
 - Operational modes or limitations are not considered
 - Reactive resources (dynamic or static devices) are not included
- For systems designed for delivering generating resource capacity (collector systems):
 - The components of the collector system are considered BES from the point where the aggregate capacity is greater than 75 MVA, including inverters, transformers, feeders, etc.
 - The individual collector lines may not be considered BES if they are not designed to deliver greater than 75 MVA of generating capacity
- Ownership of the resource(s) is not considered

NERC Registration Considerations for BESS and Hybrid Resources

The owners of resources that meet the BES Definition are required to register, per the NERC Rules of Procedure, for the appropriate functions, even if there is more than one owner. ERO Enterprise staff should consider the following points regarding Registration of owners and operators of BESS and hybrid resources within the scope of the BES Definition.

BESS

BESS resources have the ability to produce and consume active power from the BES. With regard to discharging (producing power), they operate as a generating resource. For this reason, the owner and operator of a resource within the scope of the BES Definition must register as a Generator Owner (GO) and Generator Operator (GOP), respectively. However, with respect to charging (consuming power), there are no additional NERC Registration requirements.

Hybrid Resources

Hybrid resources are similar to other BES-connected resources. Since the resource is a producer of active power, the owner(s) and operator(s) of the resources within the scope of the BES Definition must register as GO(s) and GOP(s), respectively. If the hybrid resource contains BESS, there are no additional Registration requirements with respect to charging.

Attachments: Single Line Diagrams of BESS and Hybrid Configurations

The following figures are intended to provide ERO Enterprise staff examples of possible configurations and include both text and diagrams explaining how to apply the BES Definition for the specific configuration shown. These examples are not to be considered all-inclusive and are provided for illustrative purposes only.

For the purpose of this practice guide, examples of different plant configurations will be limited to various combinations of dispersed power producing resources, focusing on BESS, solar PV, and wind, or combinations of these dispersed power producing resources with synchronous generation.

Figure 1: BESS, Aggregate Nameplate Rating 100 MVA, BES Resources

Figure 2: BESS, Aggregate Nameplate Rating 50 MVA, non-BES Resources

Figure 3: Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Figure 4: Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 70 MVA, non-BES Resources

Figure 5: 2 x Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 160 MVA, BES Resources

Figure 6: 2 x Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Figure 7: Solar PV + BESS (DC coupled), Aggregate Nameplate Rating 100 MVA, BES Resources

Figure 8: Solar PV + BESS (DC coupled), Aggregate Nameplate Rating 50 MVA, non-BES Resources

Figure 9: Wind + BESS (AC coupled), Aggregate Nameplate Rating 110 MVA, BES Resources

Figure 10: Wind + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Figure 11: Wind + BESS (AC coupled), Aggregate Nameplate Rating 70 MVA, non-BES Resources

Figure 12: Wind + Solar PV + BESS (AC Coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Figure 13: Wind + BESS (AC Coupled), Two Owners, Aggregate Nameplate Rating 80 MVA, BES Resources

Figure 14: Synchronous + BESS, Aggregate Plant Nameplate Rating 110 MVA, BES Resources

Figure 15: Synchronous + BESS, Sync. 15MVA and Aggregate Plant Rating 20 MVA, non-BES Resources

Figure 16: Synchronous + BESS, Sync. 2x 25 MVA, Aggregate Plant 70 MVA, Sync. BES Resources and BESS non-BES Resources

Figure 17: Synchronous + BESS, Sync. 4 x 15 MVA, Aggregate Plant 80 MVA, BES Resources

Key to figure color coding and annotation:

- **Blue** indicates that an Element is included in the BES
- **Green** indicates that an Element is not included in the BES
- **Orange** indicates 'points of connection'
- **Black** indicates Elements that are not evaluated for the specific exclusion depicted in the individual diagrams being shown



Reactive Resources (static or dynamic devices) are depicted as capacitors to simplify the figures. Reactive Resources do not contribute to the generation site's gross aggregate nameplate rating.

Version History

Version	Date	Action	Change Tracking
1	February 2, 2021	CMEP practice guide for “Application of the Bulk Electric System Definition to BESS and Hybrid Resources”	New

BESS site and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual 100 MVA). By application of Inclusion I4 the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

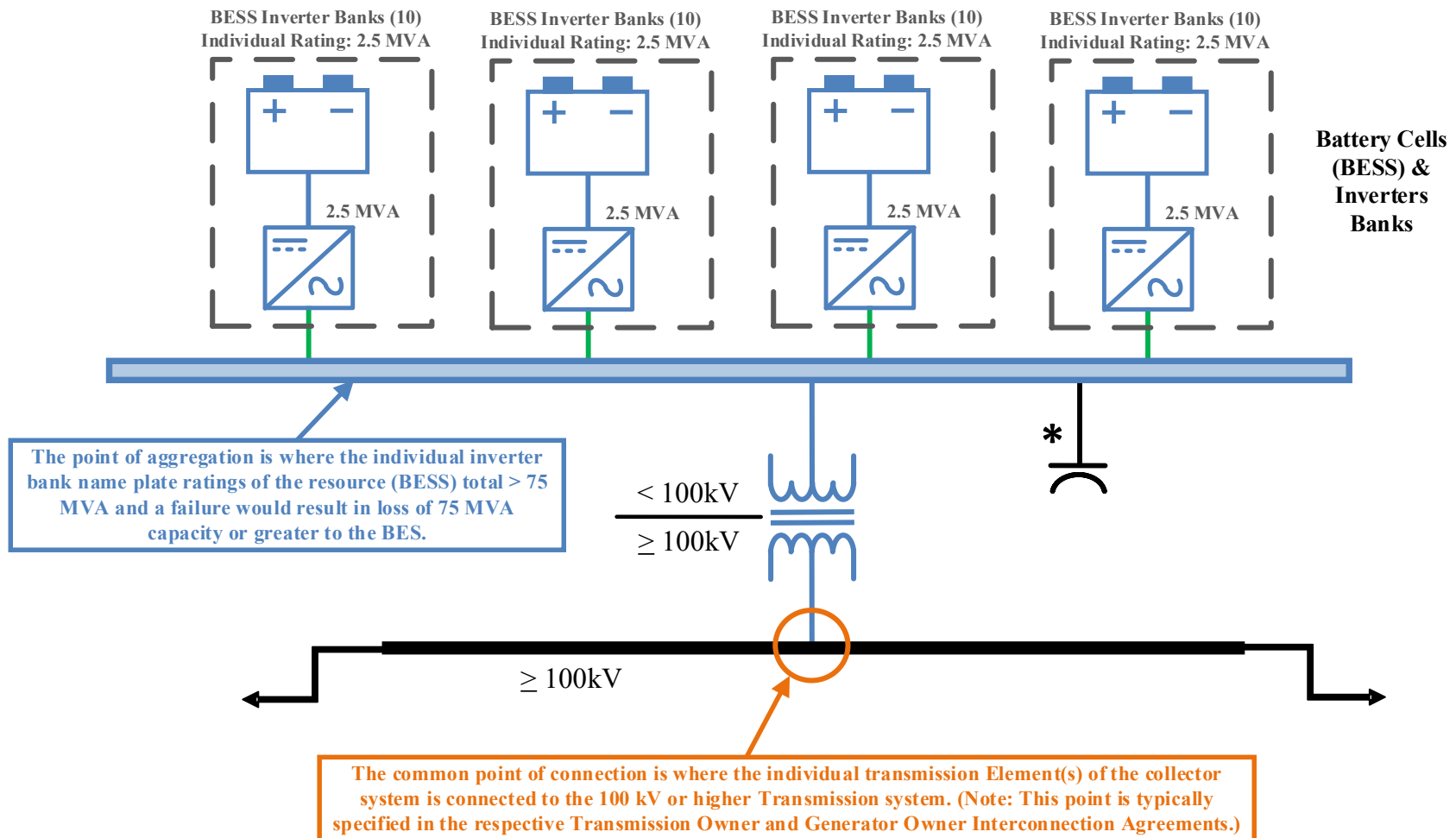


Figure 1: BESS, Aggregate Nameplate Rating 100 MVA, BES Resources

BESS site and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual 50 MVA). By application of Inclusion I4 the Battery Cells & associated Inverter Banks (BESS generator units) are excluded from the BES.

Green indicates the non-BES dispersed power producing resources (Battery Cells & associated Inverter Banks (BESS generator units)) and the non-BES portions of the Collector System.

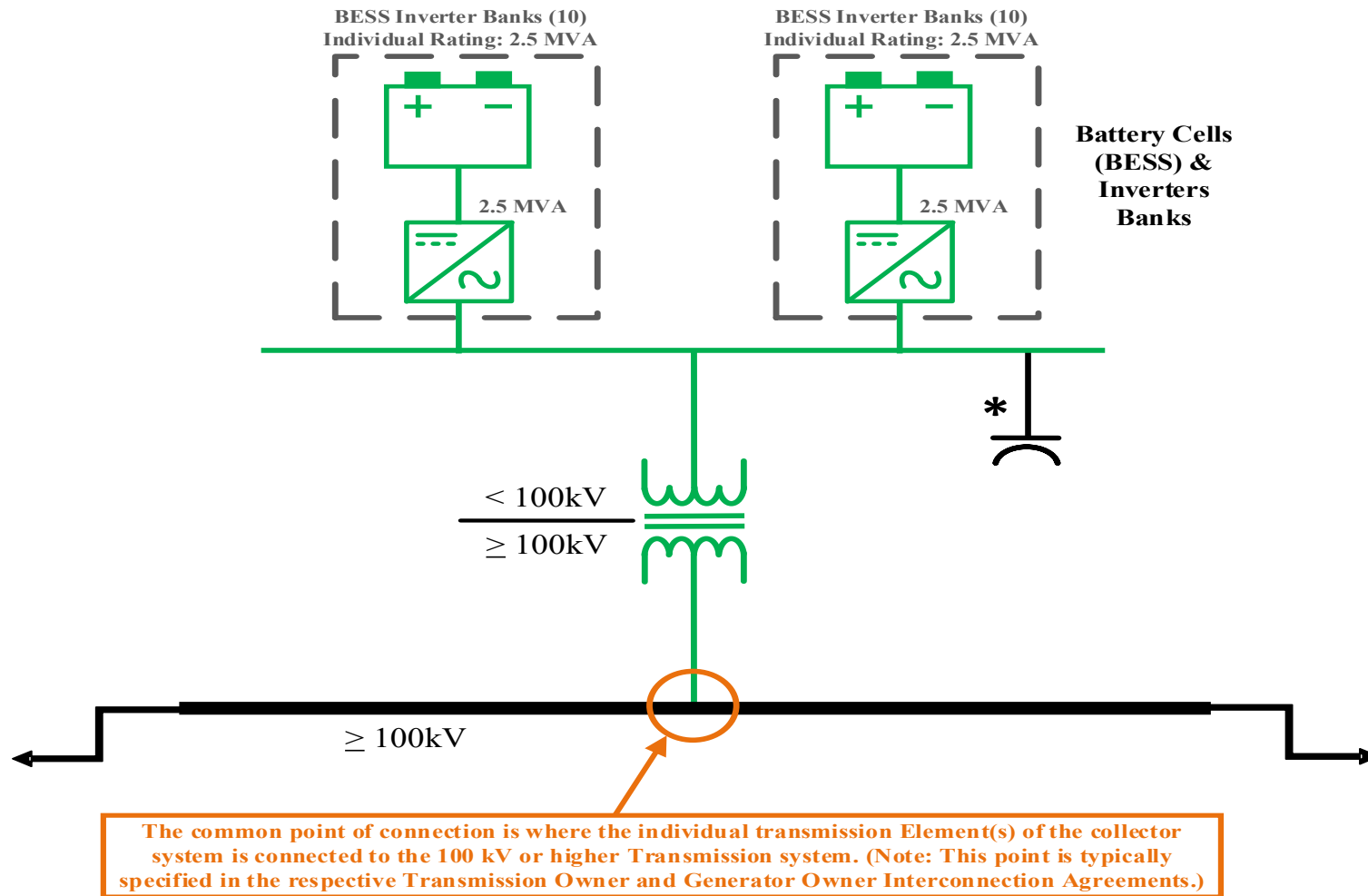


Figure 2: BESS, Aggregate Nameplate Rating 50 MVA, non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: PV (50 MVA) + BESS (30 MVA) = 80 MVA). By application of Inclusion I4 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

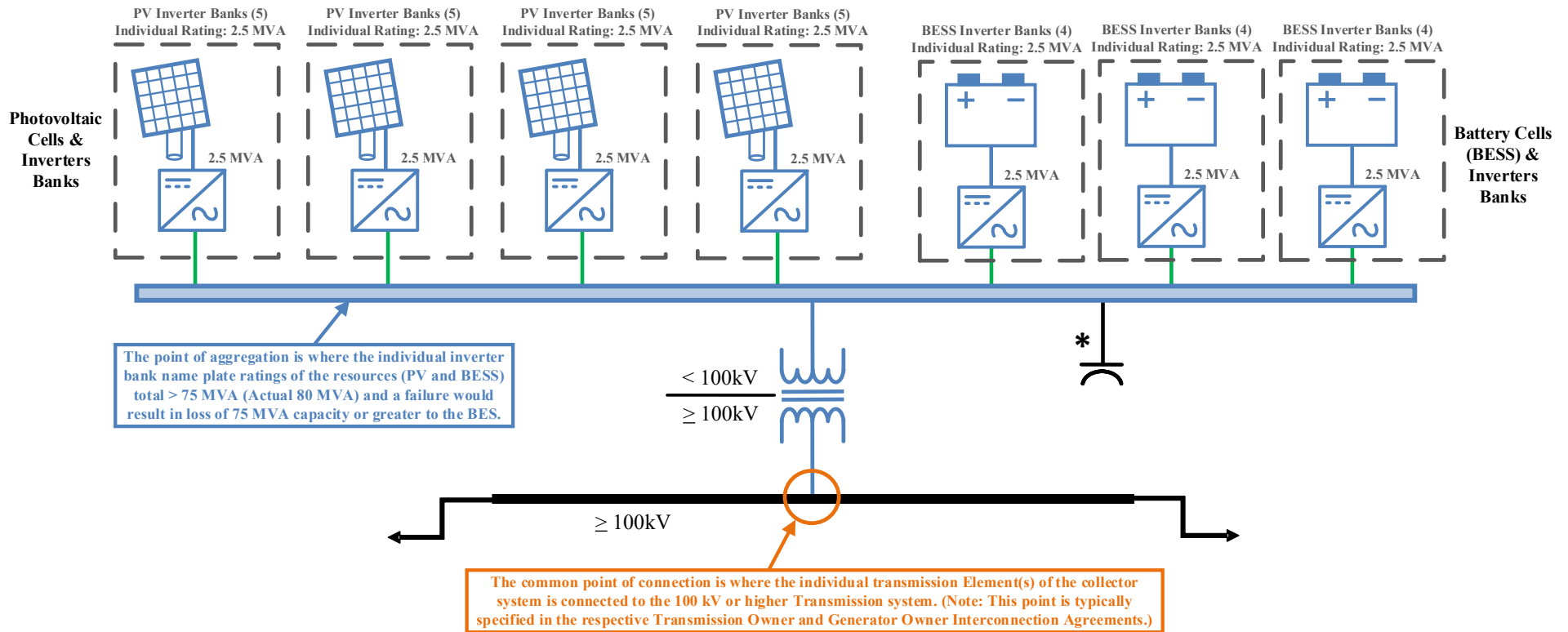


Figure 3: Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual: PV (50 MVA) + BESS (20 MVA) = 70 MVA). By application of Inclusion I4 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units) are excluded from the BES.

Green identifies non-BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units)) and the non-BES portions of the collector system.

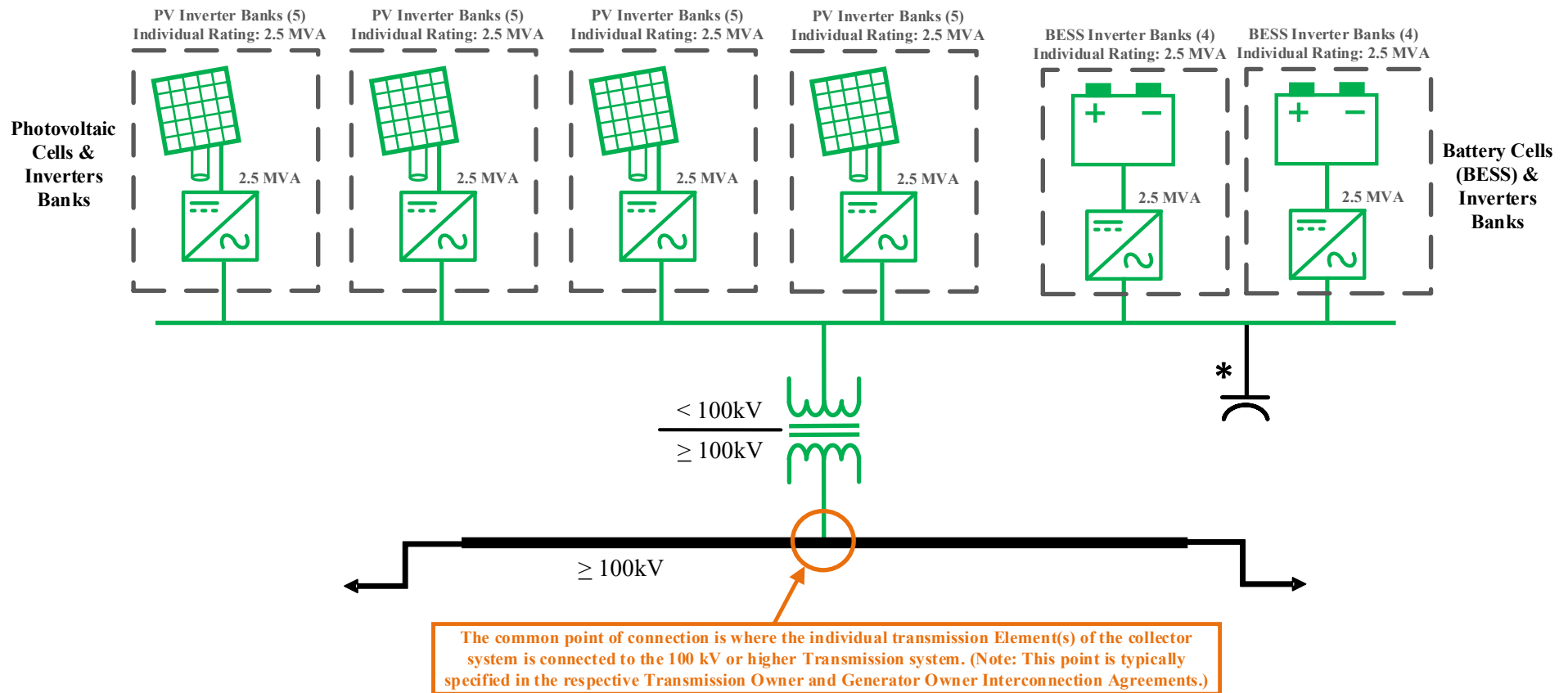


Figure 4: Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 70 MVA, non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: (PV (50 MVA) + BESS (30 MVA)) + (PV (50 MVA) + BESS (30 MVA))) = 160 MVA). By application of Inclusion 14 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

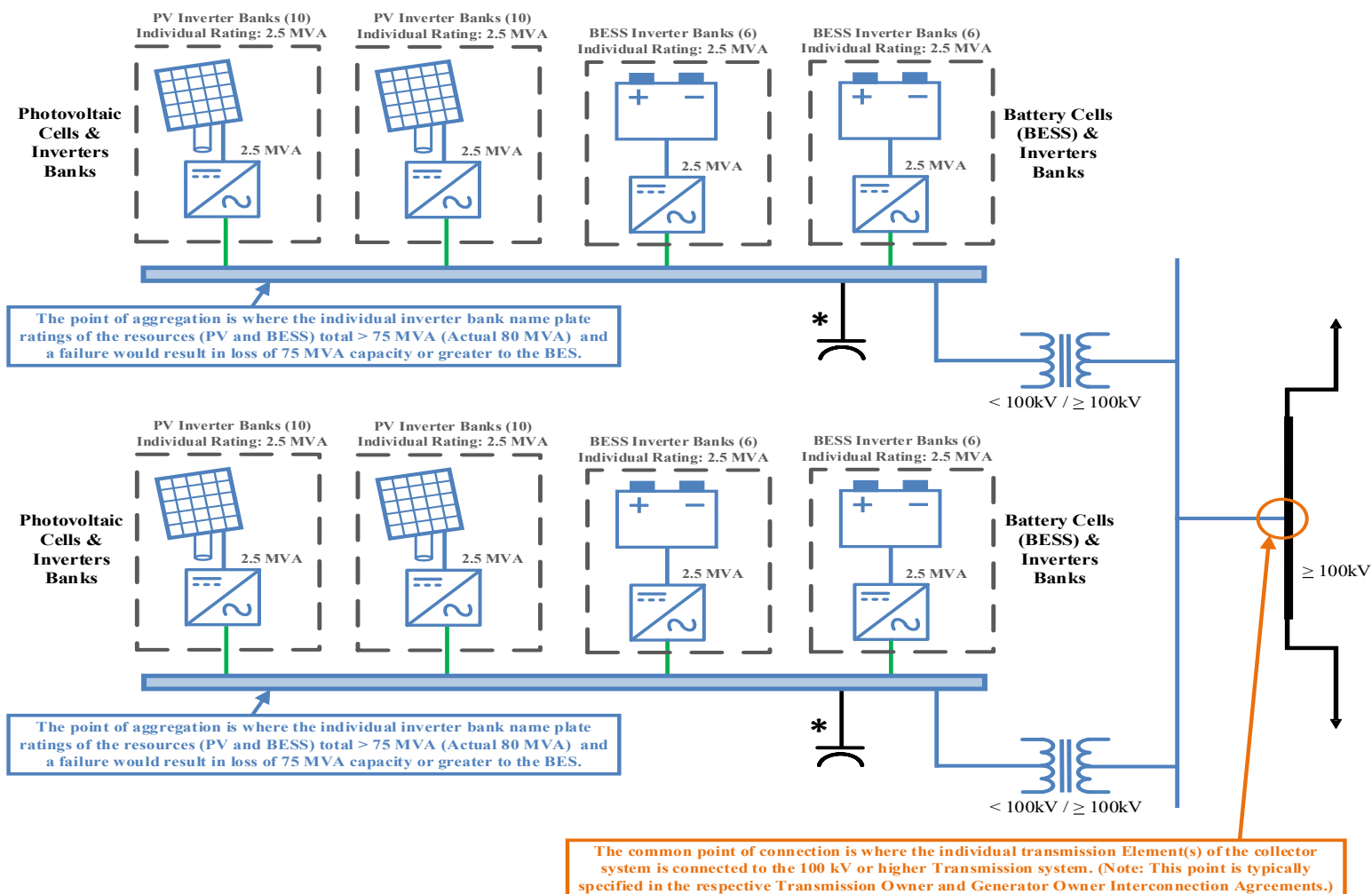


Figure 5: 2 x Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 160 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: $(PV (30 \text{ MVA}) + BESS (10 \text{ MVA})) + (PV (30 \text{ MVA}) + BESS (10 \text{ MVA})) = 80 \text{ MVA}$). By application of Inclusion I4 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

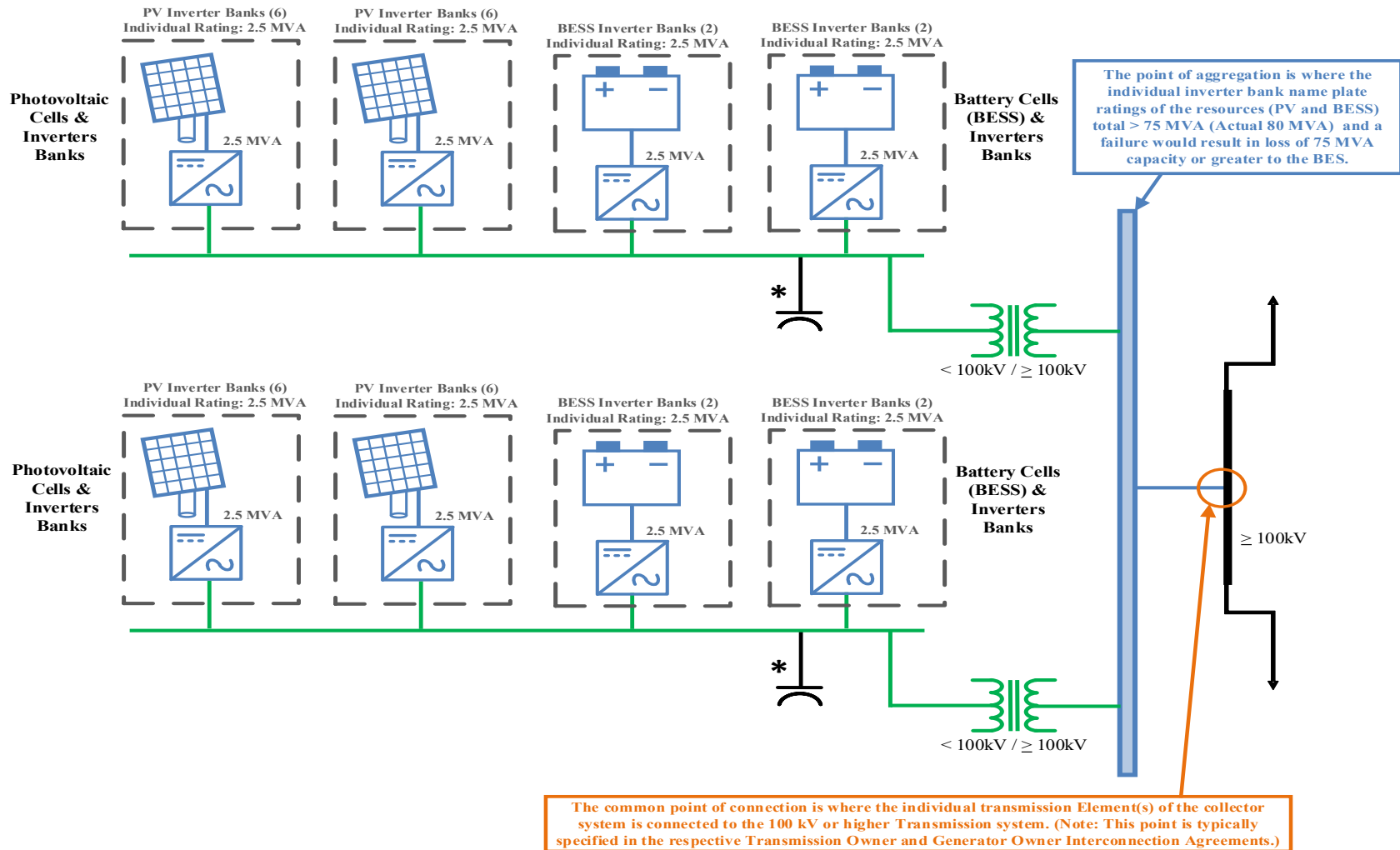


Figure 6: 2 x Solar PV + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: PV 100 MVA) = 100 MVA). By application of Inclusion I4 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Converter Banks (BESS generator units) are included in the BES.

Note: The gross aggregate nameplate rating of the DC/DC Converters (BESS generator units) does not contribute to the gross aggregate rating of the hybrid generation site due to the DC coupling with the PV Cells / Inverter Banks.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Converter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

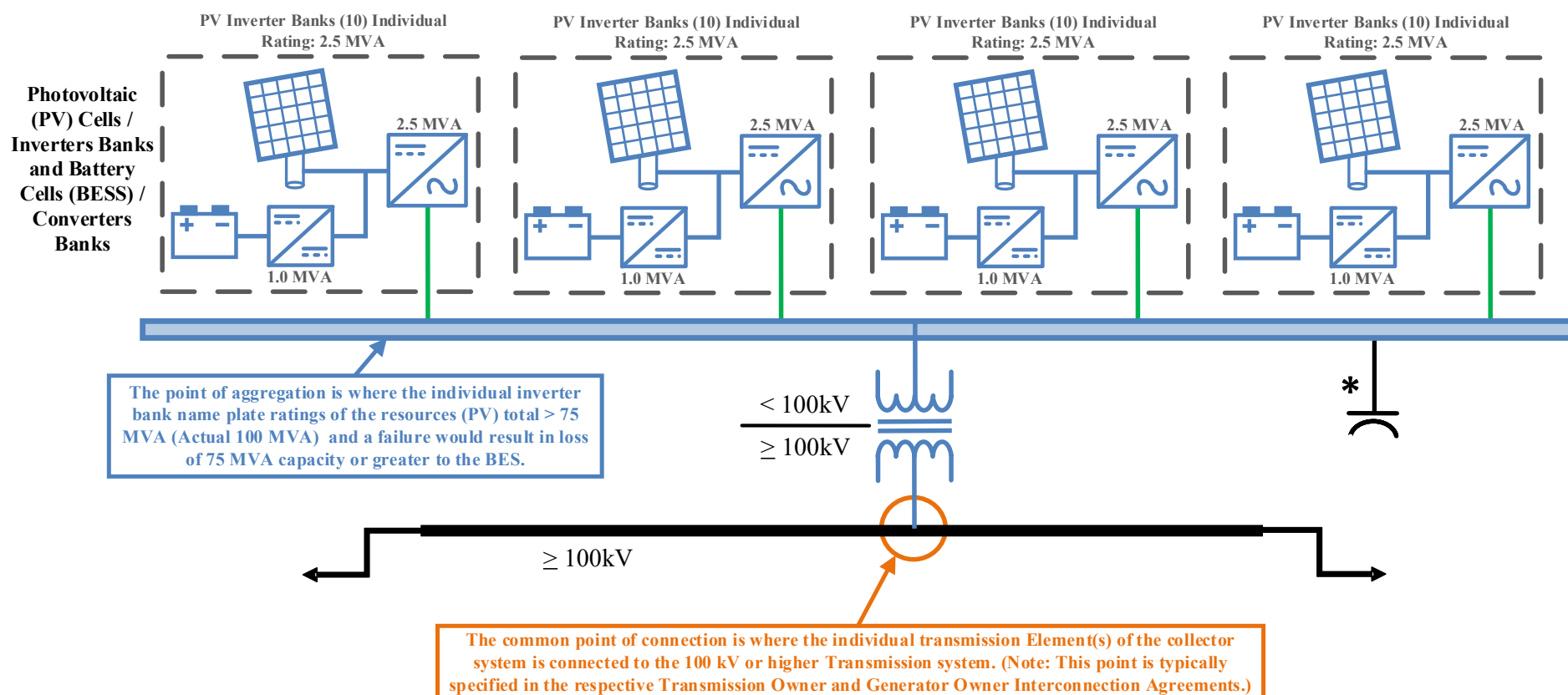


Figure 7: Solar PV + BESS (DC coupled), Aggregate Nameplate Rating 100 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual: PV 50 MVA) = 50 MVA). By application of Inclusion I4 the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Converter Banks (BESS generator units) are excluded from the BES.

Note: The gross aggregate nameplate rating of the DC/DC Converters (BESS generator units) does not contribute to the gross aggregate rating of the hybrid generation site due to the DC coupling with the PV Cells / Inverter Banks.

Green indicates the non-BES dispersed power producing resources (Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Converter Banks (BESS generator units)) and the non-BES portions of the Collector System.

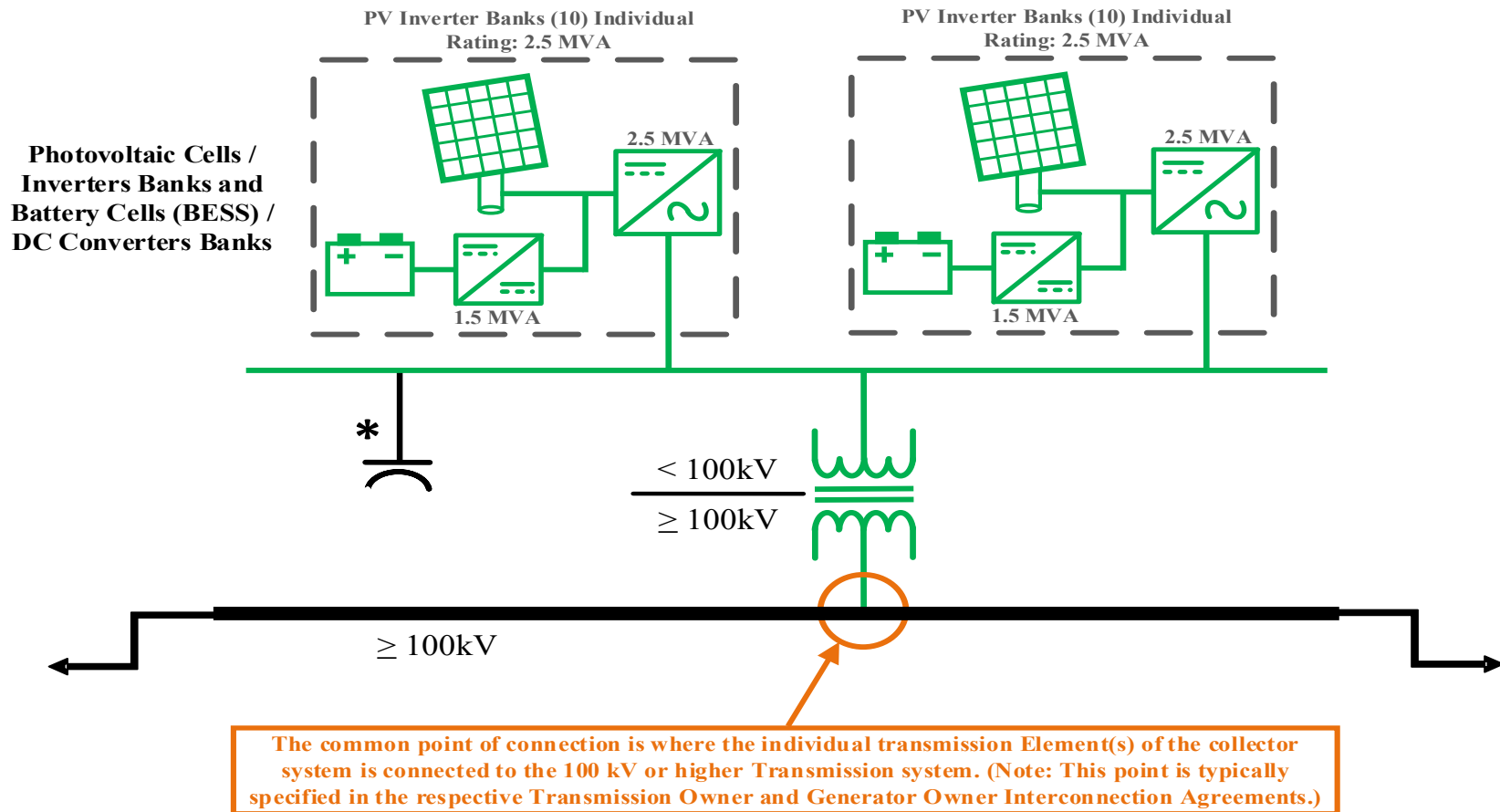


Figure 8: Solar PV + BESS (DC coupled), Aggregate Nameplate Rating 50 MVA, non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Wind (100 MVA) + BESS (10 MVA) = 110 MVA). By application of Inclusion I4 the Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

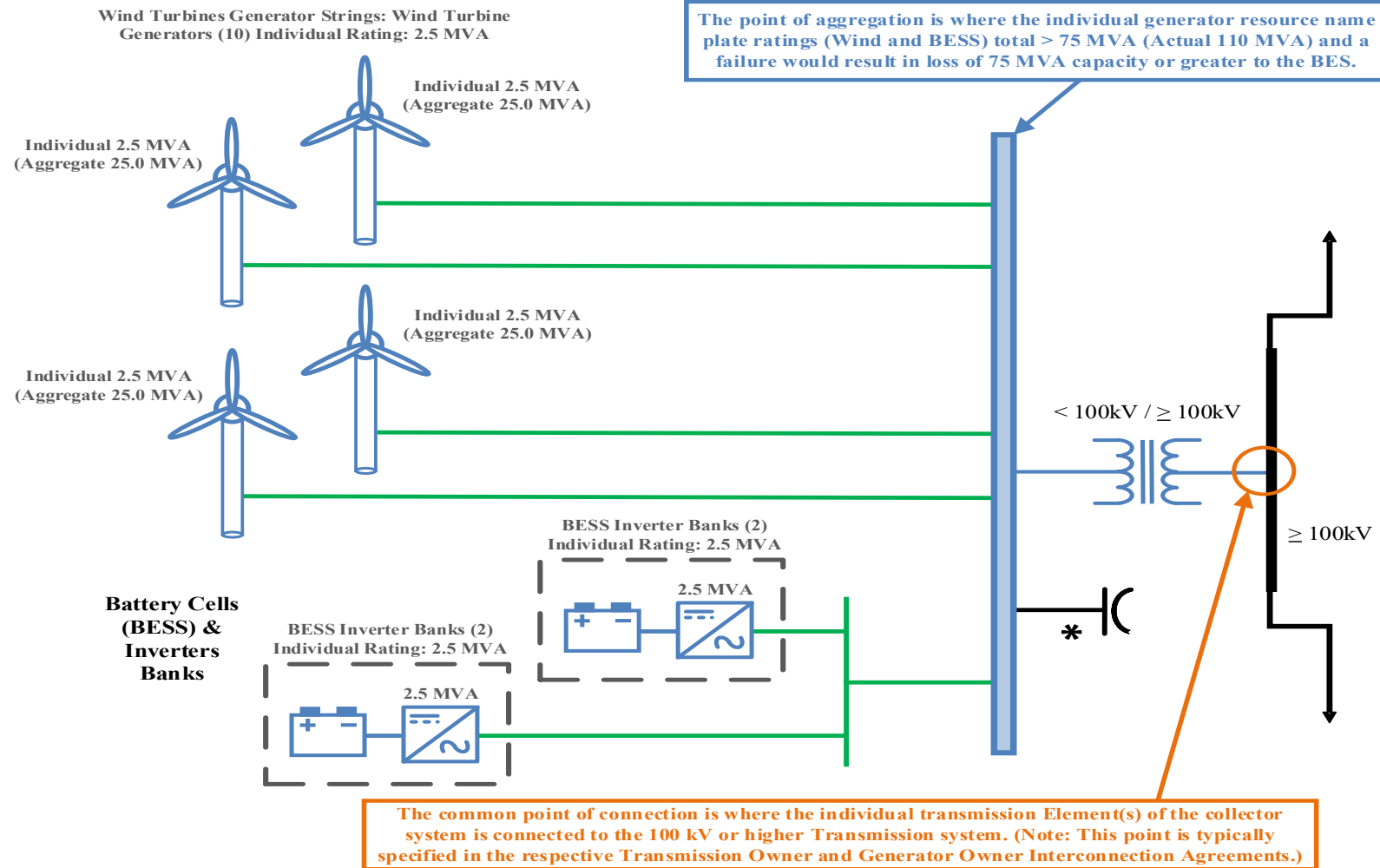


Figure 9: Wind + BESS (AC coupled), Aggregate Nameplate Rating 110 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Wind (50 MVA) + BESS (30 MVA) = 80 MVA).
 By application of Inclusion I4 the Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.
Green indicates the portions of the Collector System that are not included in the BES.
Blue identifies BES dispersed power producing resources (Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

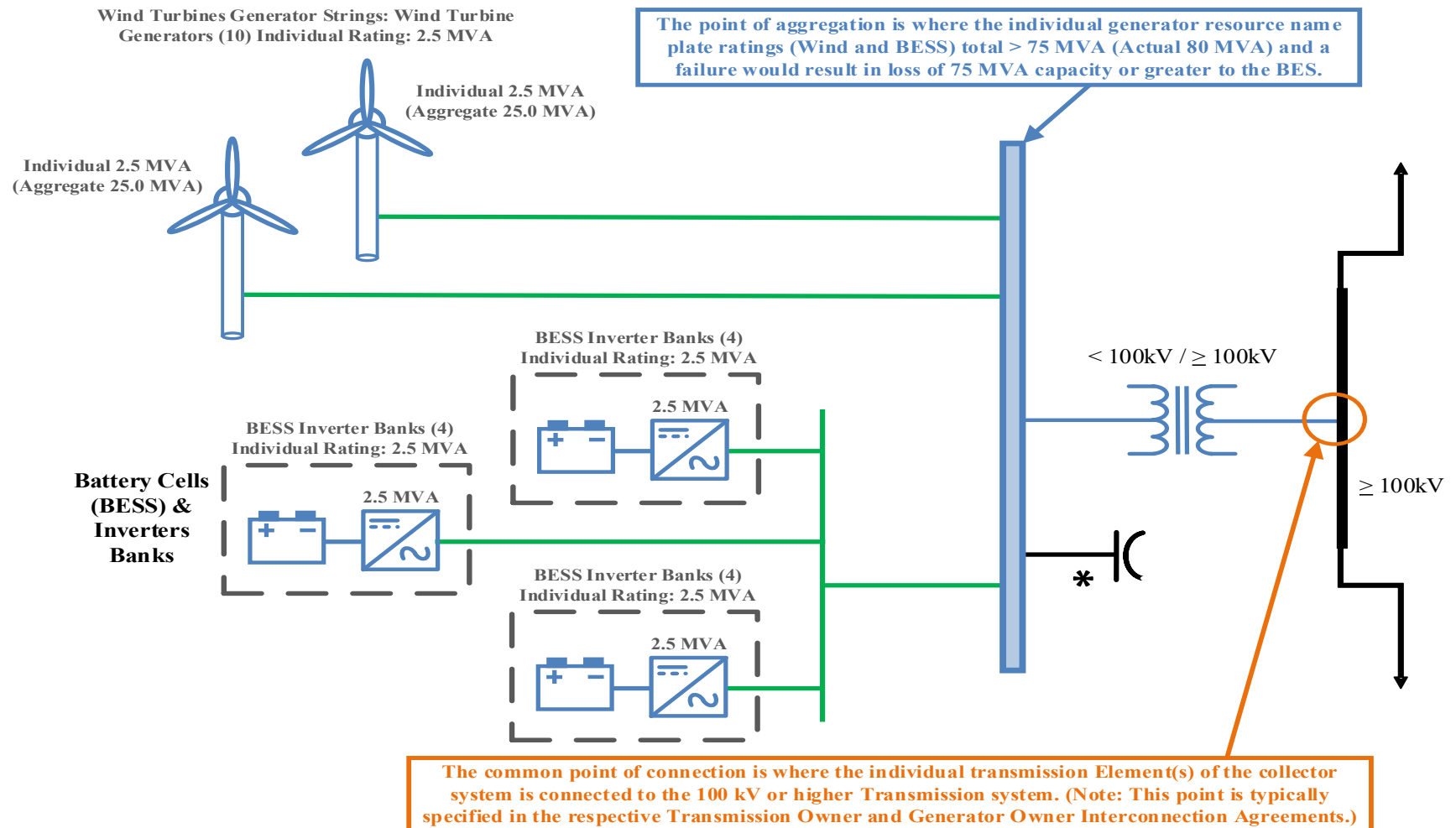


Figure 10: Wind + BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual: Wind (50 MVA) + BESS (20 MVA) = 70 MVA). By application of Inclusion I4 the Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units) are excluded from the BES. **Green indicates the non-BES dispersed power producing resources (Wind Turbine Generators and Battery Cells & associated Inverter Banks (BESS generator units)) and the non-BES portions of the Collector System.**

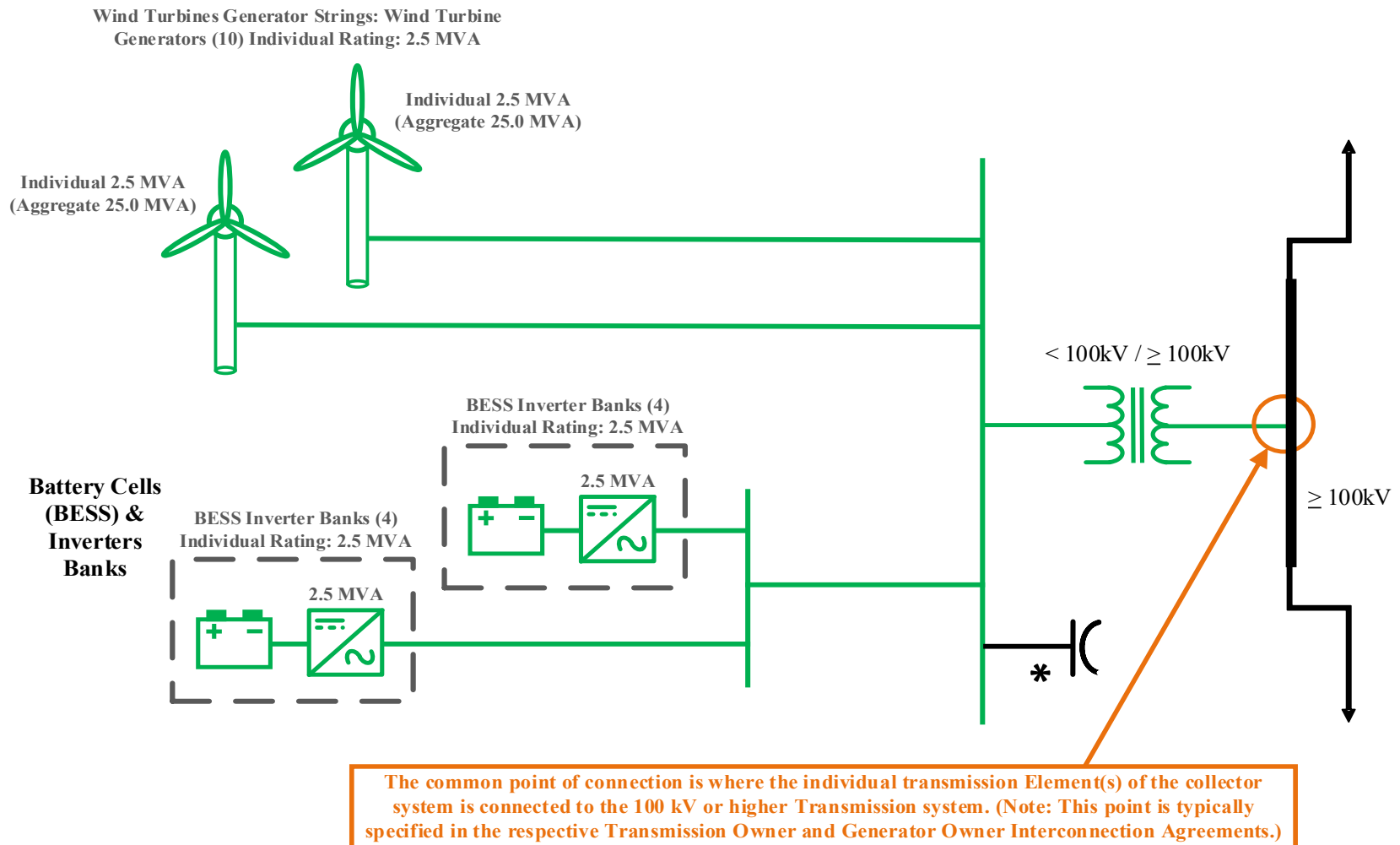


Figure 11: Wind + BESS (AC coupled), Aggregate Nameplate Rating 70 MVA, non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Wind (50 MVA) + PV (20 MVA) + BESS (10 MVA) = 80 MVA). By application of Inclusion I4 the Wind Turbine Generators, the Photovoltaic Cells & the associated Inverter Banks (solar generator units) and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the Collector System that are not included in the BES.

Blue identifies BES dispersed power producing resources (Wind Turbine Generators, the Photovoltaic Cells & the associated Inverter Banks (solar generator units), the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

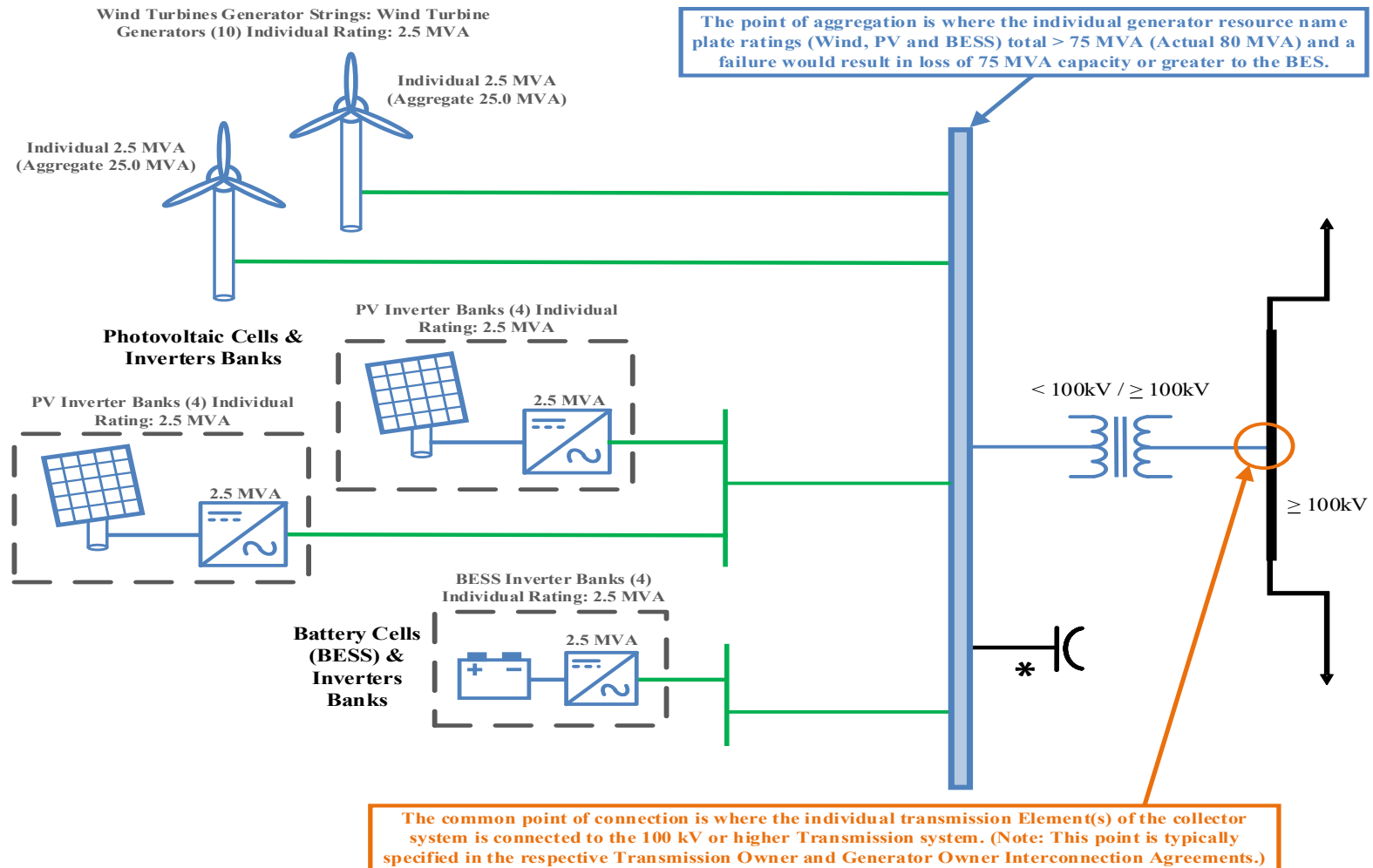


Figure 12: Wind + Solar PV+ BESS (AC coupled), Aggregate Nameplate Rating 80 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Wind (50 MVA) + BESS (30 MVA) = 80 MVA).
 By application of Inclusion I4 the Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.
Green indicates the portions of the Collector System that are not included in the BES.
Blue identifies BES dispersed power producing resources (Wind Turbine Generators and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.
 (Note: This diagram was developed to emphasize that ownership or operational responsibilities do not impact the application of the BES definition.)

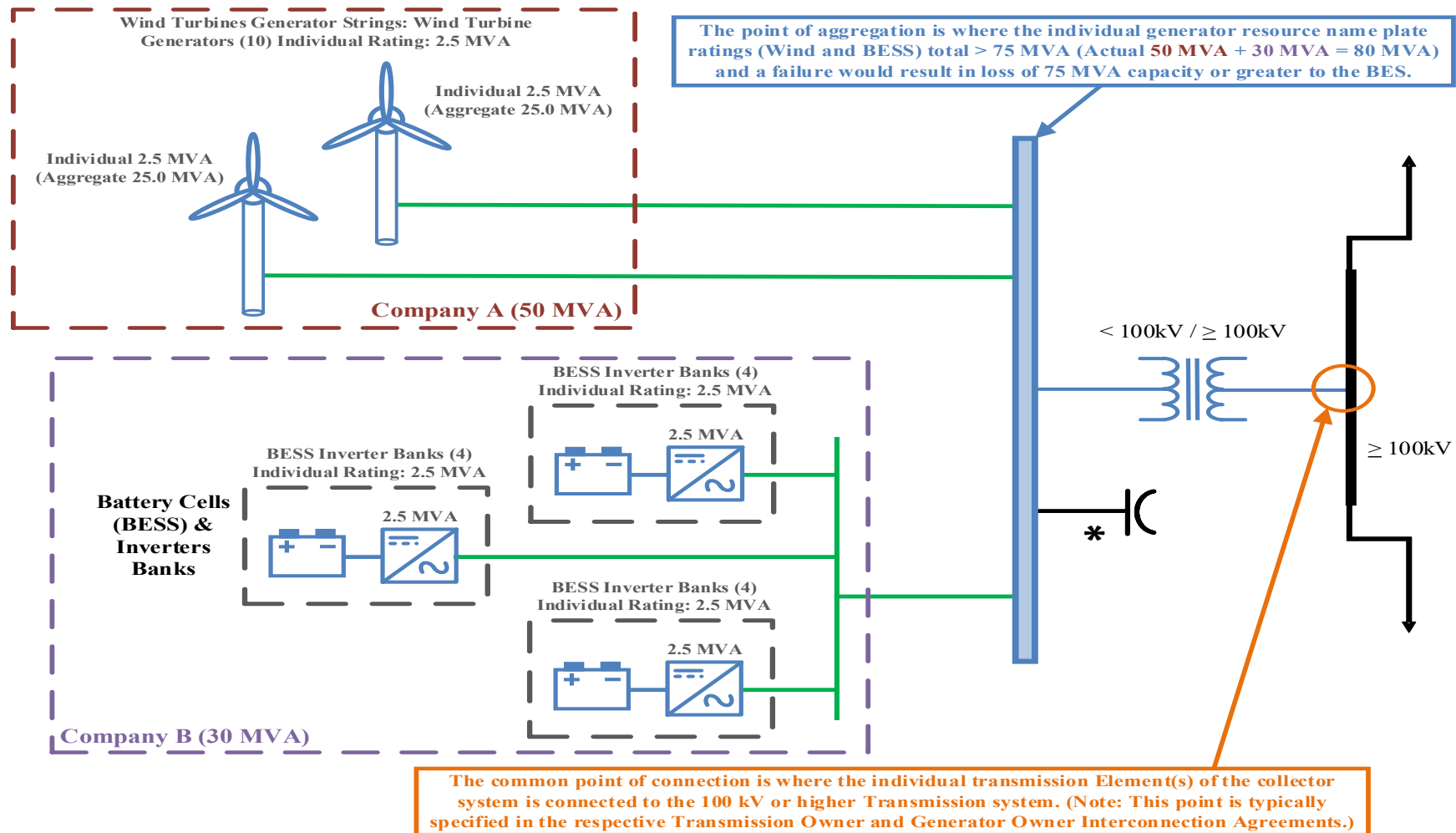


Figure 13: Wind + BESS (AC coupled), Two Owners, Aggregate Nameplate Rating 80 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Synchronous (100 MVA) + BESS (10 MVA) = 110 MVA). By application of 'gross aggregate nameplate rating' provision in Inclusion I2 and I4 the synchronous generators, including the generator terminals through the high-side of the step-up transformers, and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the facilities that are not included in the BES.

Blue identifies BES synchronous generators, including the generator terminals through the high-side of the step-up transformers, and the Battery Cells & associated Inverter Banks (BESS generator units)) and the BES Elements between the points of aggregation and the common point of connection.

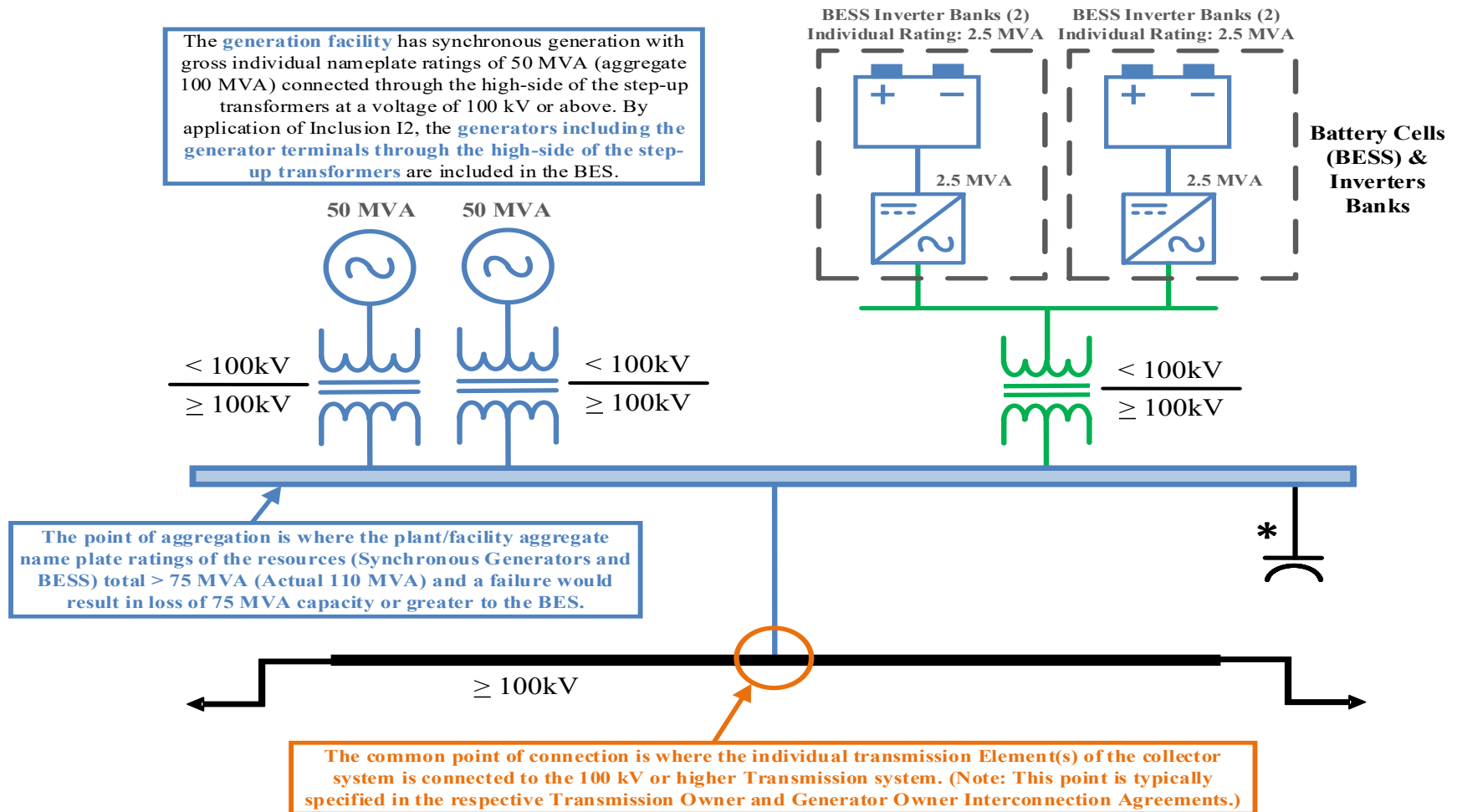


Figure 14: Synchronous + BESS, Aggregate Plant Nameplate Rating 110 MVA, BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual: Synchronous (15 MVA) + BESS (5 MVA) = 20 MVA). By application of 'gross aggregate nameplate rating' provision in Inclusion I2 and I4 the synchronous generator, including the generator terminals through the high-side of the step-up transformers, and the Battery Cells & associated Inverter Banks (BESS generator units) are excluded from the BES.

Green indicates the non-BES power producing resources (Synchronous Generator and Battery Cells & associated Inverter Banks (BESS generator units)) and the non-BES portions of the Collector System.

The **generation facility** has synchronous generation with a gross individual nameplate rating of 15 MVA connected through the high-side of the step-up transformers at a voltage of 100 kV or above. By application of Inclusion I2, the **generator including the generator terminals through the high-side of the step-up transformers** are excluded from the BES.

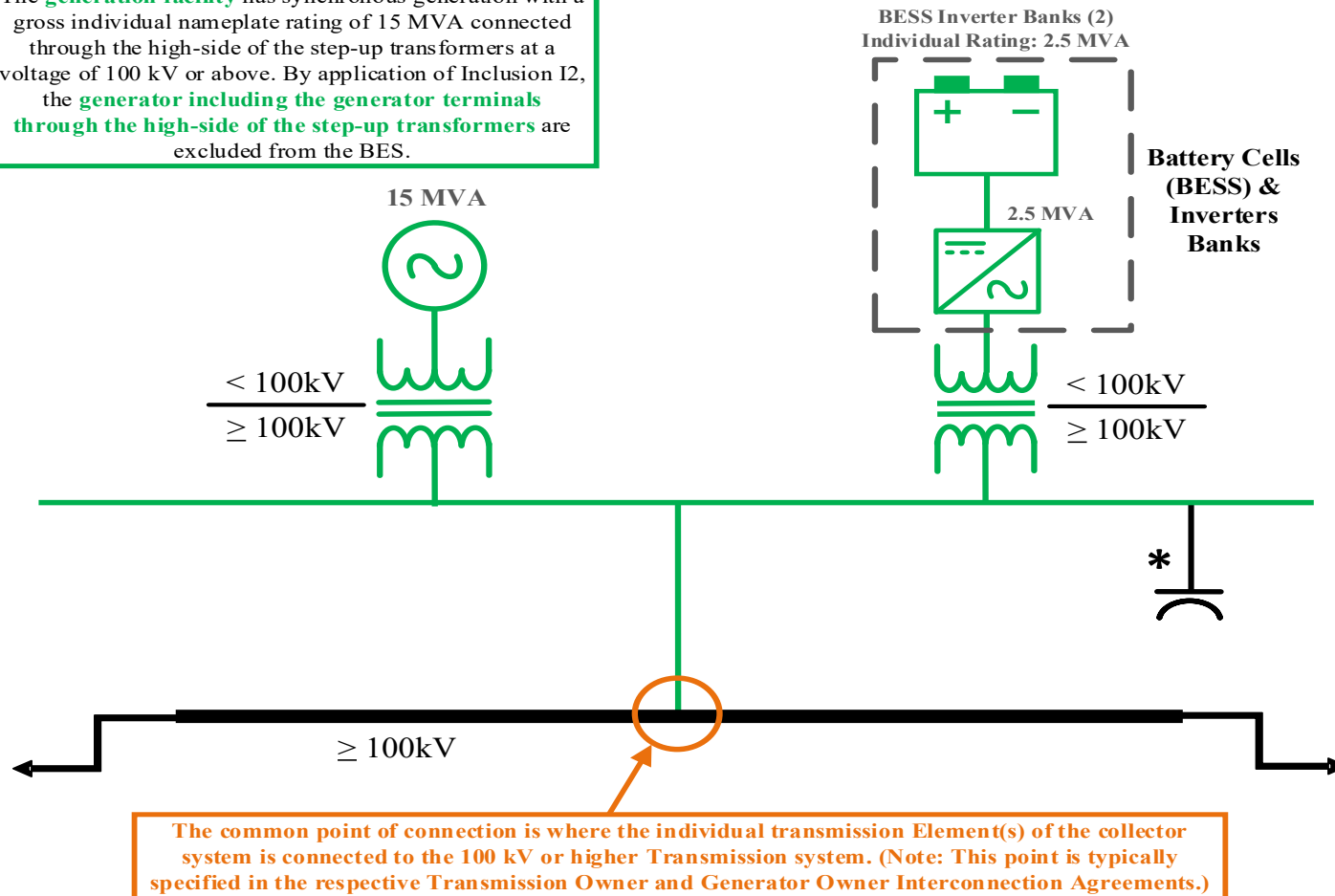


Figure 15: Synchronous + BESS, Sync. 15 MVA and Aggregate Plant Rating 20 MVA, non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of < 75 MVA (Actual: Synchronous (50 MVA) + BESS (20 MVA) = 70 MVA). By application of 'gross individual nameplate rating' provision in Inclusion I2 the synchronous generators, including the generator terminals through the high-side of the step-up transformers, are included in the BES. By application of 'gross aggregate nameplate rating' provision in Inclusion I2 and I4 the Battery Cells & associated Inverter Banks (BESS generator units) are excluded from the BES.

Blue identifies BES synchronous generators, including the generator terminals through the high-side of the step-up transformers, and the BES Elements to the common point of connection.

Green indicates the non-BES dispersed power producing resources (Battery Cells & associated Inverter Banks (BESS generator units)) and the non-BES portions of the Collector System.

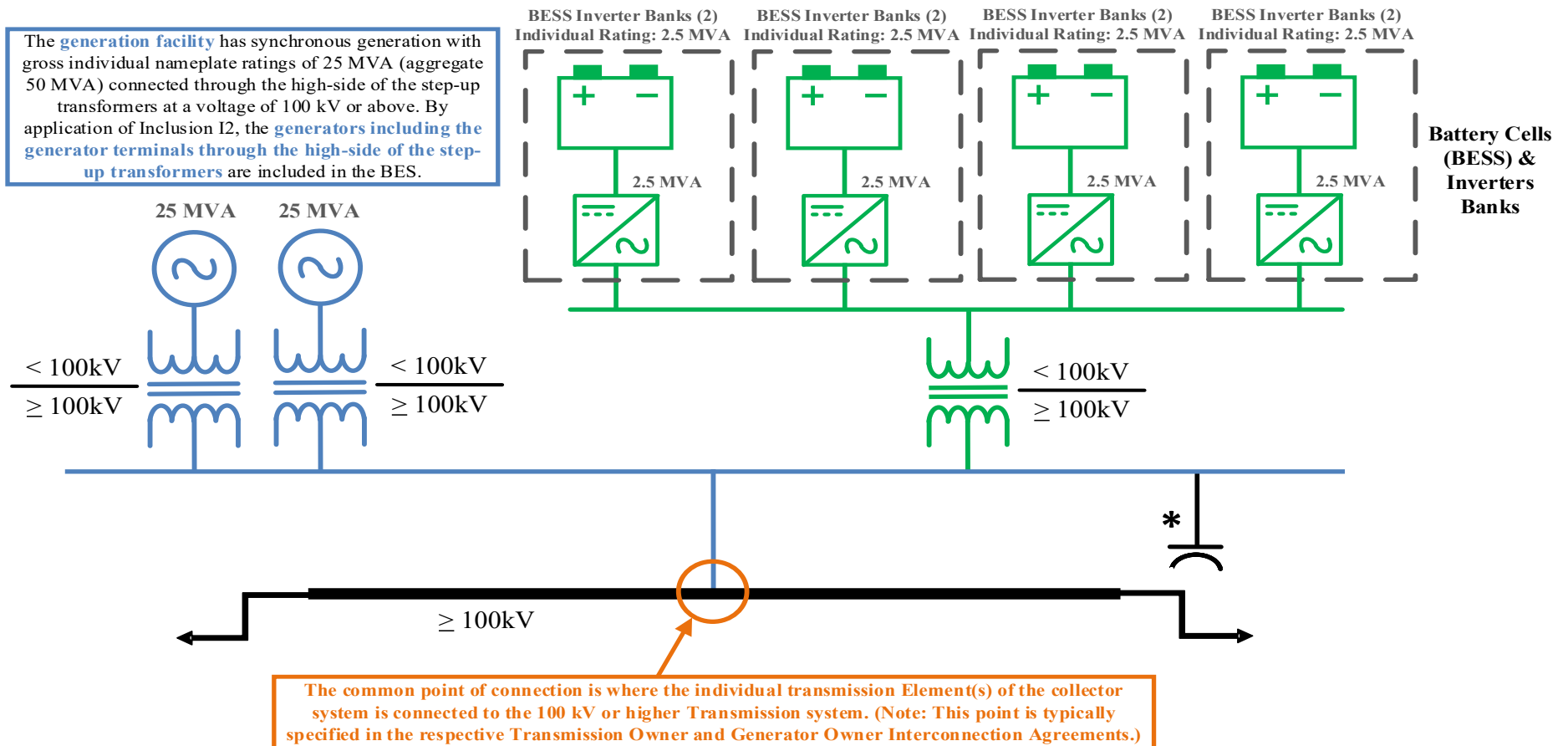


Figure 16: Synchronous + BESS, Sync. 2x 25 MVA, Aggregate Plant 70 MVA, Sync. BES Resources and BESS non-BES Resources

Hybrid generation resource and substation design with a gross aggregate nameplate rating of > 75 MVA (Actual: Synchronous (60 MVA) + BESS (20 MVA) = 80 MVA). By application of the 'gross aggregate nameplate ratings' provisions in Inclusion I2 and I4 the synchronous generators, including the generator terminals through the high-side of the step-up transformers and the Battery Cells & associated Inverter Banks (BESS generator units) are included in the BES.

Green indicates the portions of the facilities that are not included in the BES.

Blue identifies BES synchronous generators, including the generator terminals through the high-side of the step-up transformers, and the Battery Cells & associated Inverter Banks (BESS generator units) and the BES Elements between the points of aggregation and the common point of connection.

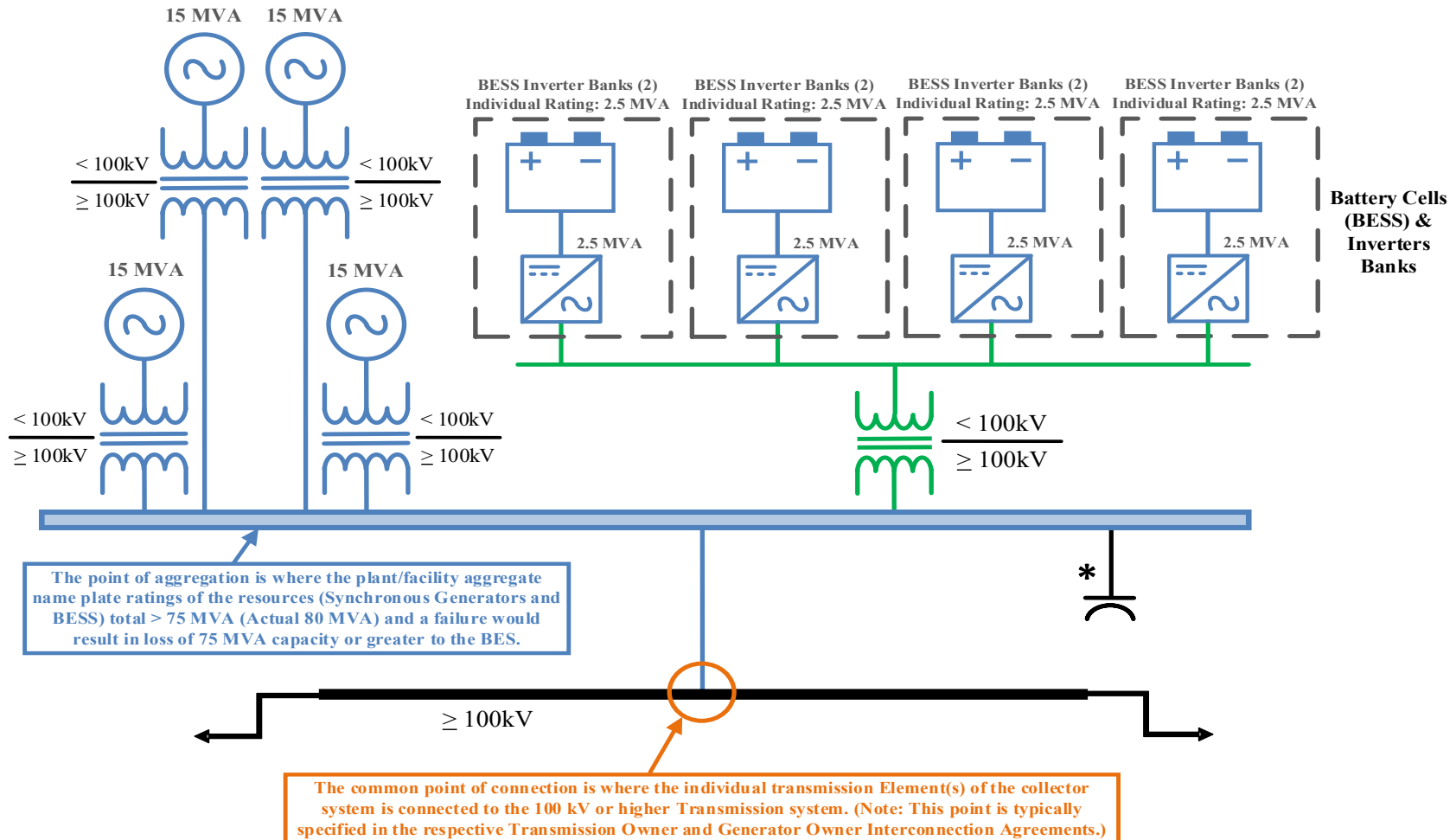


Figure 17: Synchronous + BESS, Sync. 4 x 15 MVA, Aggregate Plant 80 MVA, BES Resources