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Study of distributed energy resources

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Abstract: *Increased demands on the nation's electrical power systems and incidences of electricity shortages, power quality problems, rolling blackouts, electricity spiked prices have caused many customers to seek other sources for high-quality and reliable electricity. Distributed Energy Resources (DER) small-scale power generation resources located close to where the electricity is used (e.g., a house or commercial sectors), provide an alternate source of energy.*

DER is a faster and less expensive option for the construction of large and central power plants and also high-voltage transmission lines. They offer consumers the potential for lower cost, higher service reliability, high power quality, increased energy efficiency, and energy independence. The use of renewable distributed energy generation technologies and "green power" such as wind, photovoltaic, geothermal, biomass, or hydroelectric power can also provide a significant environmental benefit.

Keywords **-** *Distributed energy resource, electrical source, green power, power grid, renewable energy.*

I. INTRODUCTION

In 2015, the Essential Reliability Services Task Force (ERSTF) recognized that the North America's electric power system generation resource mix is changing from the use of larger synchronous sources to the use of a more diverse fleet of smaller sized resources with varying generation characteristics. As this following transformation continues, there is fundamental shift in the characteristics of operation in the power system in a whole and the potential reliability implications. The Essential Reliability Services Task Force final report provides directional measures in order to help the industry understanding and the policy makers prepare for all the ongoing transition. The measures provide the insight to the key technical aspirations that may not have considered the representative challenges with a conventional generation fleet but it may pose risks to the BPS reliability under a distinctive change in generation fleet.

The ongoing interest in this distributed electric grid and the new variations of distributed resources add further increase in the variety of stakeholders and also in the technologies. Both the new and the conventional stakeholders are building and/or planning to build the distributed solar PV systems, energy management systems (EMS), micro-grids (MGs), demand services, aggregated generating systems behind the retail meter and many other distributed generation systems. Many such kind of stakeholders have absolute considerable experience by installing such systems in the distributive network for the benefits of industrial and/or residential customers, however, they may have less similarity with the BPS system and the coordinated activities that ensure system reliability during both normal operation and in response to disturbances. While this report studies the reliability considerations from the point of view of BPS, it will also help the DER providers understanding the reliability considerations for the whole power system.

Increasing amounts of DER can also change the distribution system interaction with BPS and will also transform the distribution system for an active source of energy and ERS. Careful attention must be given to potential reliability impacts and the time frame required in order to address reliability concerns with coordination of ERS and system protection considerations, for the transmission as well as distribution system and also grow importance of information sharing within the transmission distribution interface.

Today, the effect of aggregated DER is not at all fully presented in the BPS models and also in the operating tools. This could have resulted in an unanticipated power flows and increase the demand forecast mistakes. An unexpected loss for aggregated DER could also have been caused the frequency and voltage instability at all sufficient DER penetrations. Variable output from DER can also contribute to rampage and system balance challenges for system operations which is typically not in control or in observability for the DER with the BPS.

Such issues present challenges for operational as well as planning functions of the BPS. In some areas, the DER were being connected in the distribution system at a very rapid pace but sometimes with limited coordination between the distribution utilities and also the BPS planning activities. Along with the rapid rate for DER installations in distribution systems, it will be very necessary for all the BPS planning functions to corporate future DER projects in BPS models. These changes will be affecting not just the flow of power but will also affect the behavior of the system during the distractions. It is very important to coordinate with the planning, installation and operation of DER within the BPS.

In this report of formal definition for DER is provided first which is followed by the BPS reliability considerations, modeling and DER through responses given in an event grid disturbance. Followed by the reports providing a list of NERC report with standards that also address or get affected by DER which is followed by the suggestions and the summary. Supplemental appendices that are provided along with an appendix will discuss the operational considerations.

II. HEADINGS DATA REQUIREMENTS AND INFORMATION SHARING AT THE T-D INTERFACE

With DER being connected at the distribution level but having potential impact at the BPS level, the following data and information sharing recommendations, across the T-D interface, are important to support adequate modeling and assessment of BPS reliability issues are each substation with aggregated DER data represents the mix of DER and their capabilities. Examples of DER data categories include the following:
DER type (i.e., PV, wind, cogeneration, etc.). Relevant energy production characteristics (i.e., active tracking, fixed tilt, energy storage characteristics, etc.). DER operating power factor and/or reactive and real power control functionality. DER point of common coupling (PCC) voltage. DER location: behind the meter/in front of the meter. Date that DER went into operation. A set of default equivalent impedances for various distribution grid types that can be used to choose adequate parameters (e.g., WECC’s PVD1 model for distributed PV systems), Relevant interconnection performance requirements based on national or regional standards. DER stability models and their voltage and frequency trip parameters. In particular the specific parameters of Vt0, Vt1, Vt2, and Vt3 for WECC’s distributed PV model**.** The recommended data requirements should be considered by the regional committees and specified in regional criterion such as WECC’s “Steady State and Dynamic Data Requirements MOD-(11 and 13)-WECC-CRT-1 Regional Criterion” and others.

III. DER MODELING FOR BULK POWER SYSTEM PLANNING AND OPERATIONS

While it may be desirable to model DER in all planning studies and in full detail, the additional effort of doing so may only be justified if DER are expected to have significant impact on the modeling results. An assessment of the expected impact will have to be scenario-based, and the time horizon of interest may vary between study types. For long-term planning studies, expected DER deployment levels looking 5–10 years ahead may reasonably be considered. Whether DER are modeled as BPS studies or else not, it is always recommended that the minimum data collection for DER interconnections should be established in order to assess future DER deployments.

A modular approach to represent DER in BPS studies as illustrated in Figure Modular Representation of DER in BPS Steady-State and Dynamic Studies [1, 2]. Figure is recommended to ensure absolute accurate presentation of resources for the specific BPS type study. The hierarchy of the clustering of DER for model aggregation could consider:

- Differentiation of DER per resource type to derive meaningful dispatch scenarios rather than worst-case dispatches for BPS planning studies.
- Differentiation of DER per interconnection requirements performance (i.e., the adhering interconnection standard requirements) to represent the fundamentally different steady-state and dynamic behavior among future and legacy DER.
- Differentiation of DER per technology-type (e.g., inverter coupled v/s directly coupled synchronous generator, DER) to accurately present the technology of specific dynamic behavior.

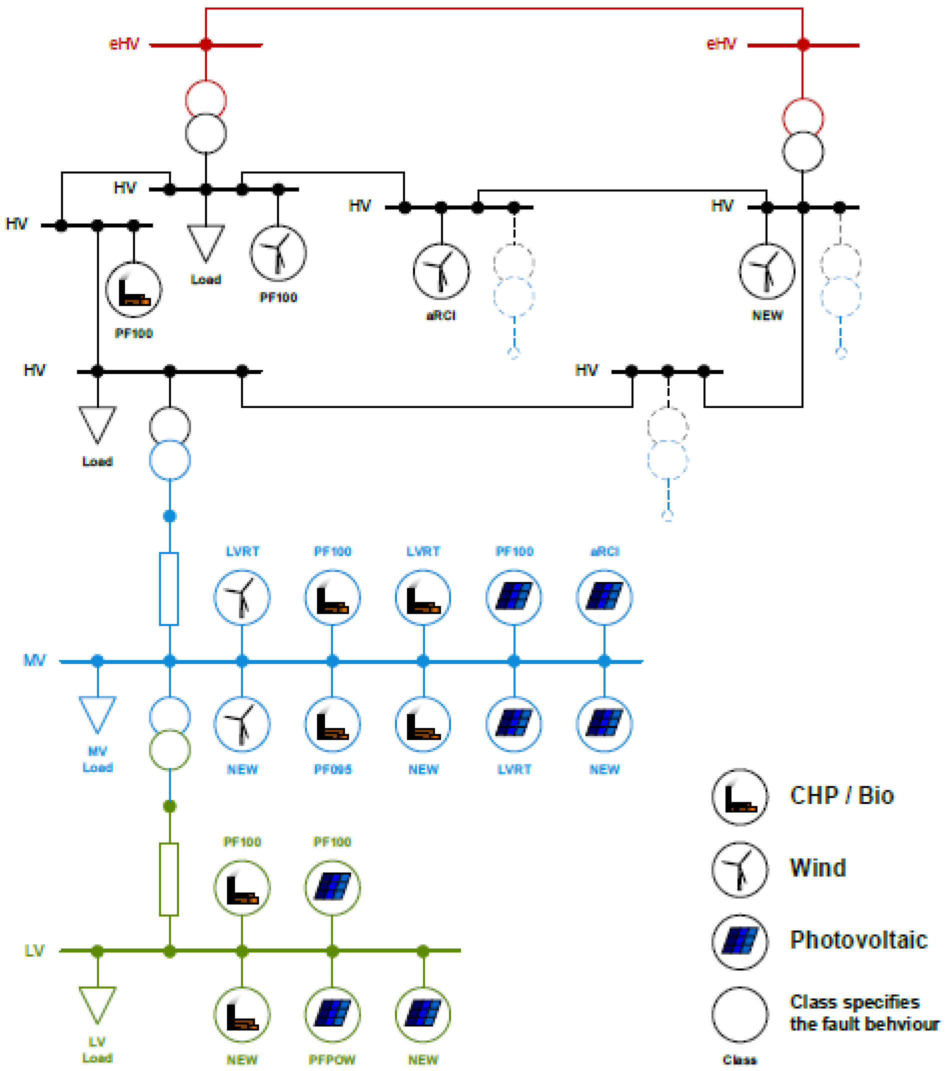

Figure 1: Modular Representation of DER in BPS Steady-State and Dynamic Studies

IV. AGGREGATED MODELING WITH NETTING OF DER WITH LOAD

In most of the existing BPS planning, the distribution system (DER) load is aggregated at all transmission buses and also netted with the generation on the distribution system. In study cases and grid areas where DER levels are expected to significantly impact power flows between the transmission and distribution system to the point that they may conflict with NERC system performance criteria (e.g., NERC TPL-001-4), DER should not be merged with load but it should be modeled in an aggregated or equivalent way in order to reflect their dynamic characteristics and/or steady-state output. Exceptions will be there for permissive netting of DER (but not explicitly modeling DER also reducing load by DER power generation based on exclusively available DER data) that may be acceptable in the steady-state studies but for those that inject real power only at power factor with unity without the ability of providing static voltage support at low DER penetration levels.

Depending on the study region, the aggregate DER penetration at substation level, regional level, or interconnection-wide level may give indication towards the expected impact of DER on the system performance; however, the decision to aggregate DER must always be system interdependent. This assessment should be carried out irrespective of whether it's behind the meter DER and/or before the meter merchant DER.

Future modeling may require the DER to be modeled separately from the load. Thresholds for aggregating DER or distinctly modeling DER may be determined by an area's specific needs. An example of a modeling threshold in order to limit overall BPS model complexity is provided by the WECC manual. The WECC manual requires:

- Modeling of any single DER with a capacity of greater than or equal to 10 MVA explicitly, and

- Modeling of multiple DER at any load bus where their aggregated capacity at the 66/69 kV substation level is greater than or equal to 20 MVA with a single-unit behind a single equivalent (distribution) impedance model as shown in Figure 2 based on WECC's "PV Power Plant Dynamic Modeling Guide".

The threshold above which DER are not netted with loads is system-specific and may depend on the study specifications, DER penetration level, and load composition. For example, in the regional case of WECC, earlier versions of the WECC Data Preparation Manual stated that a maximum amount of five percent netted generation of an area's total generation is recommended, but this statement was removed in the new version of the manual for use in 2017. In general, netting of DER with loads should be avoided.

Minimum data collection for DER modeling should be established to enable adequate assessment of future DER deployments. Related data requirements are outlined in WECC's "Steady State and Dynamic Data Requirements MOD-(11 and 13)-WECC-CRT-1 Regional Criterion"

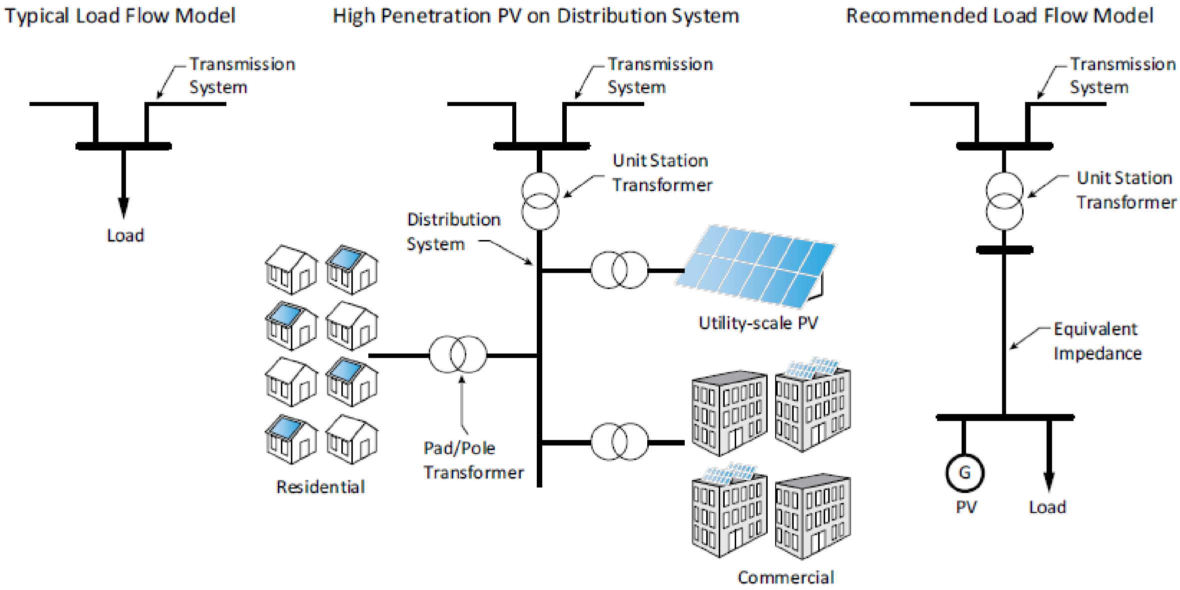

Figure 2: WECC Recommended Power Flow Representation for Study of High-Penetration PV Scenarios.

V. CONCLUSION

We can conclude by stating that we can use different methods of connection for distributed energy source. Depending upon the connectivity of the area and the available resources we can decide the method to be opted.

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AppendixD: Transmission-Distribution Interface NERC | Distributed Energy Resources Task Force Report | February 2017-42

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