Bulk Power, Distribution, and Grid Edge Services Definitions

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DOE Office of Electricity Program Manager Joseph Paladino oversees this work.

Disclaimer

Purpose

The purpose of this document is to catalog the various services that may be provided by distributed energy resources[1] (DERs) to facilitate applied research and industry discussions. It was primarily developed as a supporting reference document for the DOE's Operational Coordination and Integrated Distribution System Planning programs. This document only identifies the various existing services as defined by the Federal Energy Regulatory Commission (FERC), the North American Electricity Reliability Corporation (NERC), various state regulatory commissions, and new services under discussion in the industry.

This following list attempts to capture the range of possible services that may be applicable today and over the next decade or so. This list includes services that may be applicable in the bulk power system and distribution system and within the edge (e.g., customer and community). The definitions and performance attributes directly reference existing regulatory, industry, and other sources. In several cases, this document synthesizes several sources in an attempt to provide a more complete description. However, this should be viewed as a snapshot in time, as services will evolve along with the industry.

Note: This reference list does not make any attempt to identify which services may be applicable for any jurisdiction or which DER technologies may or may not provide any service now and in the future. Therefore, this list is intentionally jurisdictional and technology neutral.

[1] Distributed Energy Resources (DERs) as defined by FERC Order No. 2222: "Any resource located on the distribution system, any subsystem thereof or behind a customer meter. These resources may include, but are not limited to, resources that are in front of and behind the customer meter, electric storage resources, intermittent generation, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment. Definition is technology-neutral, including any eligible resource that is technically capable of providing wholesale and/or retail services through aggregation."

Bulk Power System		
Service and Definition	Performance Attributes	Source
Energy		
The generation or use of electric power by a device over a period of time, expressed in kilowatt-hours (kWh), megawatt-hours (MWh), or gigawatt-hours (GWh) as transported across a transmission system.	Requirements may vary based on the required level of availability and reliability.	**Service Definition**: U.S. Energy Information Administration (EIA)
Regulating Reserves		
Regulation service provides for the management of the minute-to-minute differences between load and resources and to correct for unintended fluctuations in generator output to comply with the North American Electric Reliability Corporation's (NERC's) Real-Power Balancing Control Performance Standards (BAL-001-1, BAL-001-2)	Allow continuous energy balance over the next 1 minute, and 20- to 30-minute time interval due to the variability in resources and load that can be called upon in response to operator dispatch.	**Service Definition**: North American Electric Reliability Corporation (NERC) Electric Power Research Institute (EPRI): Ancillary Services in the United States **Performance Attribute**: Hawaiian Electric (HECO): Grid Needs Assessment & Solution Evaluation Methodology
Frequency Response		
The ability of a system or elements of the system to react or respond to a change in system frequency for maintaining scheduled interconnection frequency at sixty cycles per second (60 Hz).	Specific requirements for each type of frequency response are provided below.	**Service Definition:** NERC
Inertial Response		
Inertial response injects stored kinetic or battery energy into the system, slowing down the decline in frequency to provide time for other reserve products (including primary frequency response	Response time in cycles.	**Service Definition:** National Renewal Energy Laboratory (NREL): An Introduction to Grid Services

[PFR], which is the next stage of reserve deployment) to detect those changes and respond accordingly.		EPRI: Ancillary Services in the United States **Performance Attribute:** NERC
Primary Frequency Response (PFR)		
Automatic and autonomous response to frequency variations through a generator's droop parameter and governor response, or energy injection by grid following inverters, or response by load.	Operate a governor or equivalent with a maximum 5% droop and ±0.036 Hz dead band and for the droop characteristic to be based on the nameplate capacity. Response time in seconds to tens of seconds.	**Service Definition:** HECO: Grid Needs Assessment & Solution Evaluation Methodology **Performance Attribute:** Federal Energy Regulatory Commission (FERC) Order No. 842 Pacific Northwest National Laboratory (PNNL): Grid Architecture Power System Glossary
Fast Frequency Response (FFR)		
Fast frequency response combines characteristics of inertia and primary frequency response. It is essentially an energy injection that is provided almost immediately following a frequency deviation, that provides support by reducing the rate of change of frequency thereby increasing the minimum frequency, and reducing the steady-state frequency deviation due to a more continuous injection.	Response time in fractions of seconds (but not instantaneously like inertia) after an event.	**Service Definition and Performance Attribute:** EPRI: Ancillary Services in the United States
Secondary Frequency Response		
To maintain grid frequency and to honor scheduled energy flows between different Balancing Authorities (BA). It is measured through NERC CPS1, CPS2 (retired), and the new BAAL (balancing authority area control error limit) score requirements.	Response time in 5–15 minutes.	**Service Definition and Performance Attribute:** PNNL: Grid Architecture Power System Glossary NERC
Tertiary Frequency Response		

Maintain scheduled energy flows between different BAs to maintain the BA generation-load balance (load-following reserve) or maintain grid reliability under N-1 contingencies (spinning and non-spinning reserve). Tertiary balancing service is provided by the spinning and non-spinning reserve units.	Response time from 5 to 15 minutes to 30 minutes or longer if replacement is through market response.	**Service Definition and Performance Attribute:** PNNL: Grid Architecture Power System Glossary
Operating Reserves		
The active power capacity above firm system demand required to provide for regulation, load forecasting error, equipment forced and scheduled outages, and local area protection. It consists of spinning and non-spinning reserve.	The speed of response is also a characteristic of the type of operating reserve as described below.	**Service Definition:** NERC EPRI: Ancillary Services in the United States **Performance Attribute:** EPRI: Ancillary Services in the United States
Operating Reserves (Spinning)		
Spinning reserve is the capability of resources synchronized to the system and fully available to serve load within the Disturbance Recovery Period following the contingency event; or load fully removable from the system within the Disturbance Recovery Period following the contingency event.	All independent system operators (ISOs) require the response time to be 10 minutes to allow for 5 minutes for communication. On any particular resource, the capability for secondary contingency reserves is typically limited by 10 minutes of ramp rate from the set point of a spinning unit up to its maximum operating level or, in the case of non-spinning reserve, how much it can provide when starting up and synchronizing within 10 minutes. The response time is based on NERC Standard BAL-002, the contingency event recovery period, which requires that Area Control Error (ACE) be returned to its pre-disturbance value within 15 minutes.	**Service Definition and Performance Attribute:** EPRI: Ancillary Services in the United States
Operating Reserves (Non-Spinning)		

Non-spinning reserves are energy-producing resources that are offline but can respond to dispatch instructions.	Generation and responsive load that is offline but can be fully responsive within 30 minutes and load that can respond to dispatch in time frames that exceed 10 minutes.	**Service Definition and Performance Attribute:** PNNL: Grid Architecture Power System Glossary
Operating Reserves (Tertiary)		
Tertiary or contingency reserve is used after spinning and non-spinning reserves are employed in the case of a contingency. It is procured to replace reserve capacity prior to a second contingency event to ensure operating reserves are restored to the required amount soon after the contingency.	Resources, including offline units and load, with the ability to respond to dispatch instructions in 30–60 minutes.	**Service Definition and Performance Attribute:** PNNL: Grid Architecture Power System Glossary EPRI: Ancillary Services in the United States
Reactive Power and Voltage Support		
The ability to control leading and lagging reactive power on the system to maintain appropriate voltage levels and acceptable voltage bandwidths, to maximize efficient transfer of real power to the load under normal and contingency conditions, and to provide for operational flexibility under normal and abnormal conditions.	Reactive power and voltage support is location specific and requires the injection and absorption of reactive power from generating units and transmission assets (e.g., capacitor banks, static VAR compensators). Voltage must be kept generally within 5% or 10% of their nominal levels.	**Service Definition:** EPRI: Ancillary Services in the United States **Performance Attribute:** NERC
Ramping		
The ability of a resource to ramp active power upward or downward in a certain amount of time. It is typically measured on a MW/min basis.	Upward and downward flexible capacity to support 15-minute and 5-minute markets. Sufficient ramping capacity is needed to meet the needs of both the upcoming 15-minute market runs and the three 5-minute market runs within that 15-minute interval. Procurement in the 5-minute market is aimed at ensuring that enough ramping capacity is available to manage differences between consecutive 5-minute market intervals.	**Service Definition:** NERC **Performance Attribute:** California Independent System Operator (CAISO): Flexible Ramping Product Uncertainty – Calculation and Implementation Issues
Energy Imbalance		
Energy imbalance service is provided when a difference occurs between the scheduled and	Response time within 60 minutes.	**Service Definition:** FERC Schedule 4

actual delivery of energy to a load located within a control area over a single hour.		
Black Start		
The ability to energize a bus, meeting the transmission operator's restoration plan needs for real and reactive power capability, frequency, and voltage control (and that has been included in the transmission operator's restoration plan).	Capability to meet: • Real and reactive power requirements of the cranking paths and the dynamic capability to supply initial loads. • Location and magnitude of loads required to control voltages and frequency within acceptable operating limits. • Required to control voltages and frequency within acceptable operating limits.	**Service Definition:** NERC **Performance Attribute:** NERC
Transmission Capacity		
A non-transmission alternative (NTA) supply and/or a load-modifying service that provides as required via reduction or increase of power or load that is capable of reliably and consistently reducing net loading on desired transmission infrastructure.	Requirements are situation specific.	**Service Definition:** HECO: Grid Needs Assessment & Solution Evaluation Methodology

Distribution System		
Distribution Voltage-Reactive Power		
The ability to control leading and lagging reactive power on the system to maintain appropriate voltage levels and acceptable voltage bandwidths (ANSI C84.1), to maximize efficient transfer of real power to the load under normal and contingency conditions, and to provide for operational flexibility under normal and abnormal conditions.	Remain on standby, ready and able to detect when the distribution voltage drops rapidly, and act instantly and autonomously by rapidly adjusting net load in the form of its reactive and/or real power components within ~1 second (less is preferred).	**Service Definition Performance Attribute**: U.S. Department of Energy (DOE): Grid Services from DER Device Fleet
Distribution Capacity		
A non-wires alternative (NWA) supply and/or a load-modifying service that provides as required via reduction or increase of power or load that is	Distribution capacity service can be provided by a single resource and/or an aggregated set of resources that reduce the net loading on a	**Service Definition**:

capable of reliably and consistently reducing net loading on desired distribution infrastructure.	specific infrastructure location coincident with the identified operational need in response to a control signal from the utility.	HECO: Non-Wires Opportunity: Evaluation Methodology HECO: Grid Needs Assessment & Solution Evaluation Methodology
Power Quality		
Services that satisfy power quality requirements regarding flicker and harmonics should be within acceptable levels.	Response time in cycles.	**Service Definition Performance Attribute**: PNNL: Grid Architecture Power System Glossary
Resilience		
Supply-based services capable of improving local distribution resilience and reliability within a microgrid. This service may also involve fast reconnection and availability of excess reserves to reduce demand when restoring customers' abnormal configurations.	Reconnection response time, if applicable, is sub-second to less than 30 seconds. Minimum of 24 consecutive hours of energy. Ability to maintain acceptable service voltage (ANSI C84.1) and frequency (nominally 60 Hz) bandwidths.	**Service Definition Performance Attribute**: California Public Utilities Commission (CPUC): Competitive Solicitation Framework and Utility Regulatory Incentive Pilot CPUC: Community Microgrid Incentive Program p. 21
Energy		
The production or use of electric power by a device over a period of time, expressed in kilowatt-hours (kWh) or megawatt-hours (MWh), as transported within a distribution system.	Requirements may vary based on the required level of availability and reliability.	**Service Definition:** EIA (adapted)

Edge		
Energy		
The production or use of electric current by a device over a period of time, expressed in kilowatt-hours (kWh) or megawatt-hours (MWh), as transported behind a metered grid connection	Requirements may vary based on the required level of availability and reliability.	**Service Definition**: EIA (adapted)

point or a microgrid islanding point within a community microgrid boundary.		
Distribution Voltage-Reactive Power		
The ability to dynamically control leading and lagging reactive power on the distribution system to maintain appropriate voltage levels and acceptable voltage bandwidths (ANSI C84.1), to maximize efficient transfer of real power to the load under normal and contingency conditions.	Response time within 1 second or less.	**Service Definition Performance Attribute**: DOE: Grid Services from DER Device Fleet
Power Quality		
Services that satisfy electric service power quality requirements, including flicker and harmonics within acceptable levels.	Response time in cycles.	**Service Definition Performance Attribute**: PNNL: Grid Architecture Power System Glossary
Resilience		
Energy-based service to supply connected net customer loads as determined by a typical load profile within the microgrid boundary during island mode when disconnected from the power grid at the islanding point.	Reconnection response time, if applicable, is sub-second to less than 30 seconds. Minimum of 24 consecutive hours of energy. Ability to maintain acceptable service voltage (ANSI C84.1) and frequency (nominally 60 Hz) bandwidths.	**Service Definition**: CPUC: Community Microgrid Incentive Program p. 21