NERC DER Modeling in Planning Studies

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DER Workshop

November 7, 2018

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NERC DER Definition

- **A Distributed Energy Resource (DER) is any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the BES.**
  - DER include any non-BES resource located solely within the boundary of any distribution provider, including the following:
    - Distributed generation, behind the meter generation, energy storage, DER aggregation, micro-grid, cogeneration, back-up generation

NERC DER Type Definitions[1]

- **Distributed Generation (DG)**
  - Any non-BES generating unit or multiple generating units at a single location owned and/or operated by 1) the distribution utility, or 2) a merchant entity
- **Behind the Meter Generation (BTMG)**
  - A generating unit or multiple generating units at a single location (regardless of ownership), of any nameplate size, on the customer's side of the retail meter that serve all or part of the customer's retail load with electric energy. All electrical equipment from and including the generation set up to the metering point is considered to be behind the meter. This definition does not include BTMG resources that are directly interconnected to BES transmission.
- **Energy Storage Facility (ES)**
  - An energy storage device or multiple devices at a single location (regardless of ownership), on either the utility side or the customer's side of the retail meter. May be any of various technology types, including electric vehicle charging stations.

1. The definitions contained in this presentation are taken from the NERC Report "Distributed Energy Resources – Connection Modeling and Reliability Considerations" (Feb. 2017), available at: https://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/Distributed_Energy_Resources_Report.pdf

NERC DER Type Definitions

- **DER Aggregation (DERA)**
  - A virtual resource formed by aggregating multiple DG, BTMG, or ES devices at different points of interconnection on the distribution system. The BES may model a DERA as a single resource at its 'virtual' point of interconnection at a particular T-D interface even though individual DER comprising the DERA may be located at multiple T-D interfaces.
- **Micro-grid (MG)**
  - An aggregation of multiple DER types behind the customer meter at a single point of interconnection that has the capability to island. May range in size and complexity from a single 'smart' building to a larger system such as a university campus or industrial/commercial park.
- **Cogeneration**
  - Production of electricity from steam, heat, or other forms of energy produced as a by-product of another process.
- **Emergency, Standby, or Back-up Generation (BUG)**
  - A generating unit, regardless of size, that serves in times of emergency at locations and by providing the customer or distribution system needs. This definition only applies to resources on the utility side of the customer retail meter.

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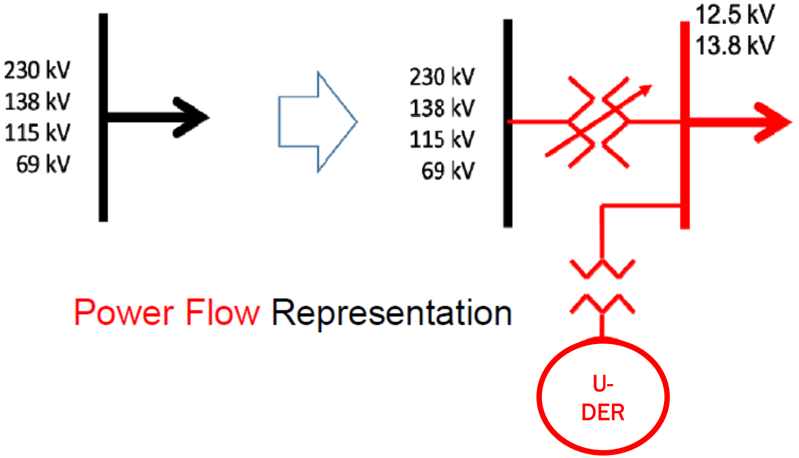
NERC DER Classifications

- Utility-Scale DER: DER directly (or closely) connected to the distribution bus or connected through a dedicated, non-load serving feeder. These resources are specifically three-phase interconnections and can range in capacity and control complexity.

- Retail-Scale DER: DER that offsets customer load. R-DER represents the truly distributed resources throughout the distribution system whose controls are generally reflective of IEEE 1547.

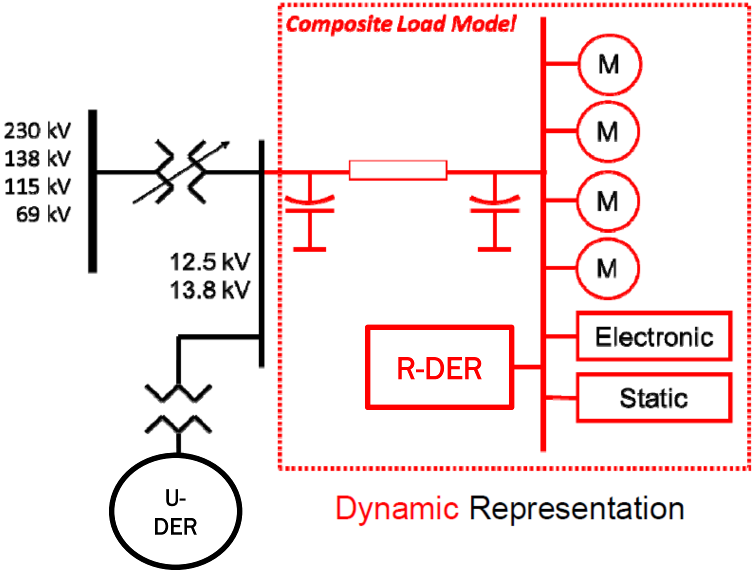
- NERC recommends that PCs develop thresholds for appropriate modeling of U-DER and R-DER in planning models.

NERC DER Classifications in Models
U- DER



NERC DER Classifications in Models
R-DER

Dynamic Load Representation



Dynamic Representation

Data Needed for Modeling DER

- **U-DER**
  - Type of generating resource (e.g., wind, solar, battery, etc)
  - Distribution bus nominal voltage where the U-DER is connected
  - Feeder characteristics for connecting U-DER to distribution bus (if applicable)
  - Transmission-Distribution interface transformer
  - Capacity of each U-DER resource
  - Control modes – voltage, frequency, active-reactive priority
  - Dynamics models

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Data Needed for Modeling DER

- R-DER
  - Aggregate capacity of R-DER for each feeder or load as represented in the model
  - Vintage of IEEE 1547-2018 or other relevant interconnection standard requirements that specify DER performance
  - As available, aggregate information characterizing the distribution circuits where R-DER are connected.

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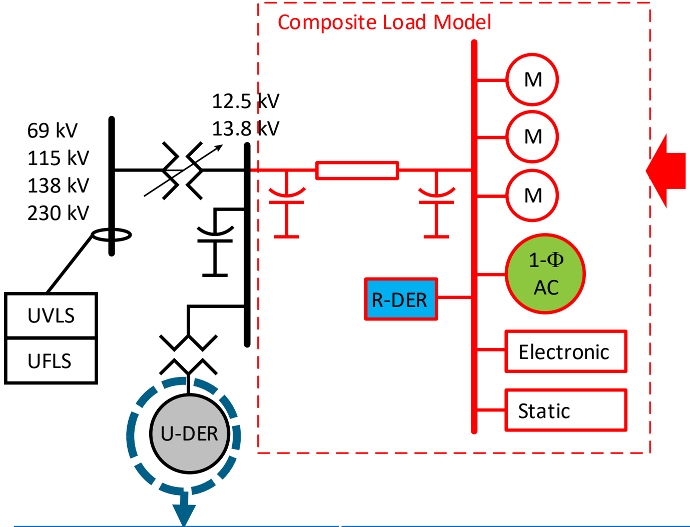
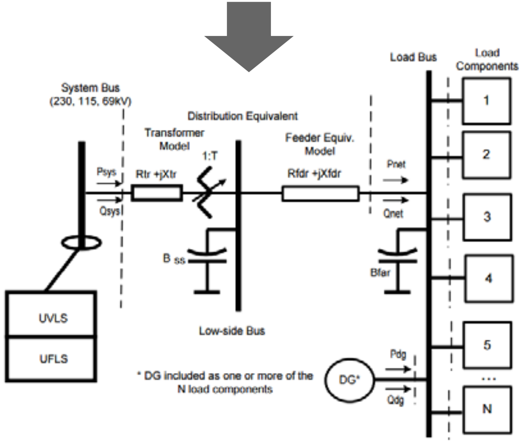
Representation of DER and Composite Load Model



Model	R-DER Representation#
cmpldwg	Inherently negative load. Can alternatively be added as an additional source
cmpldw2	Modular structure with PVD1 or DER_A

U-DER Representation	Model#
Detailed and specific	REGC_A REEC_A/REEC_B/REEC_C REPC_A
Simple and aggregate	PVD1 or DER_A



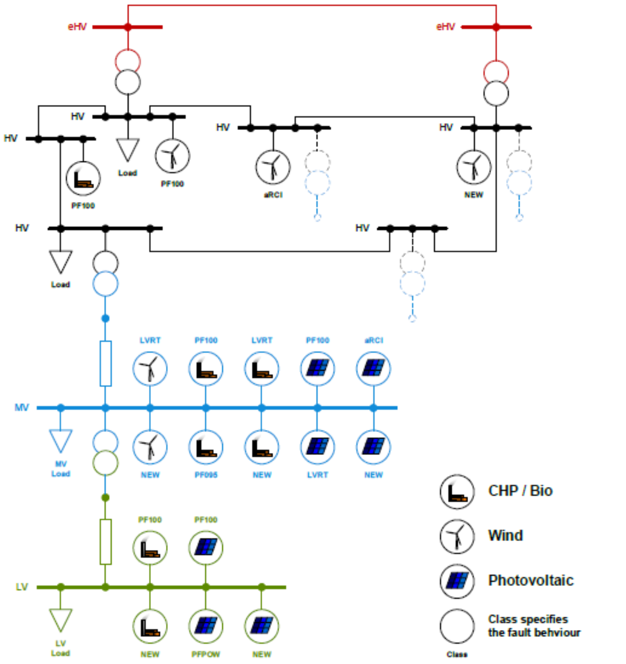
Source: Document – W. W. Price, May 18, 2016, *WECC Dynamic Composite Load Model (2nd Generation) Proposed Structure*

Limiting Capabilities of DER modeling in PSS/E

- CMPLDWG and PVD1 are not available in PSS/E current version
  - This will be available in Version 34
- Stand-alone DER_A model is recently developed and under commercial vendor testing phase

Complex Problems of Load Modeling and DER Resources

- Current practices net DER with loads at the substation level
- NERC recommends avoiding the netting of DER with loads
  - This is subject to the accurate DER models available for system modeling
- All components of the system must be represented in the models, either directly or in an aggregated way, to provide meaningful and accurate simulation results



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NERC Standards and Guidelines

- NERC Reliability Guideline "Modeling Distributed Energy Resources In Dynamic Load Models" December 2016
  - Provides a common framework for entities to consider for modeling DER in transient stability and powerflow simulations

- NERC Reliability Guideline "Distributed Energy Resource Modeling" September 2017
  - Provides information relevant for developing models and model parameters to represent different types of U-DER and R-DER in the planning models

NERC Standards and Guidelines

- NERC Reliability Guideline "Distributed Energy Resource Connection Modeling and Reliability Considerations" February 2017
  - Provides a common framework for entities to consider for modeling DER in transient stability and powerflow simulations

Recent events on Inverter Based Resources

Blue Cut Fire Event on August 16, 2016

Canyon 2 Fire Event on October 9, 2017

Source: https://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf
Source: https://www.nerc.com/pa/rrm/ea/October%209%202017%20Canyon%202%20Fire%20Disturbance%20Report/900%20MW%20Solar%20Photovoltaic%20Resource%20Interruption%20Disturbance%20Report.pdf

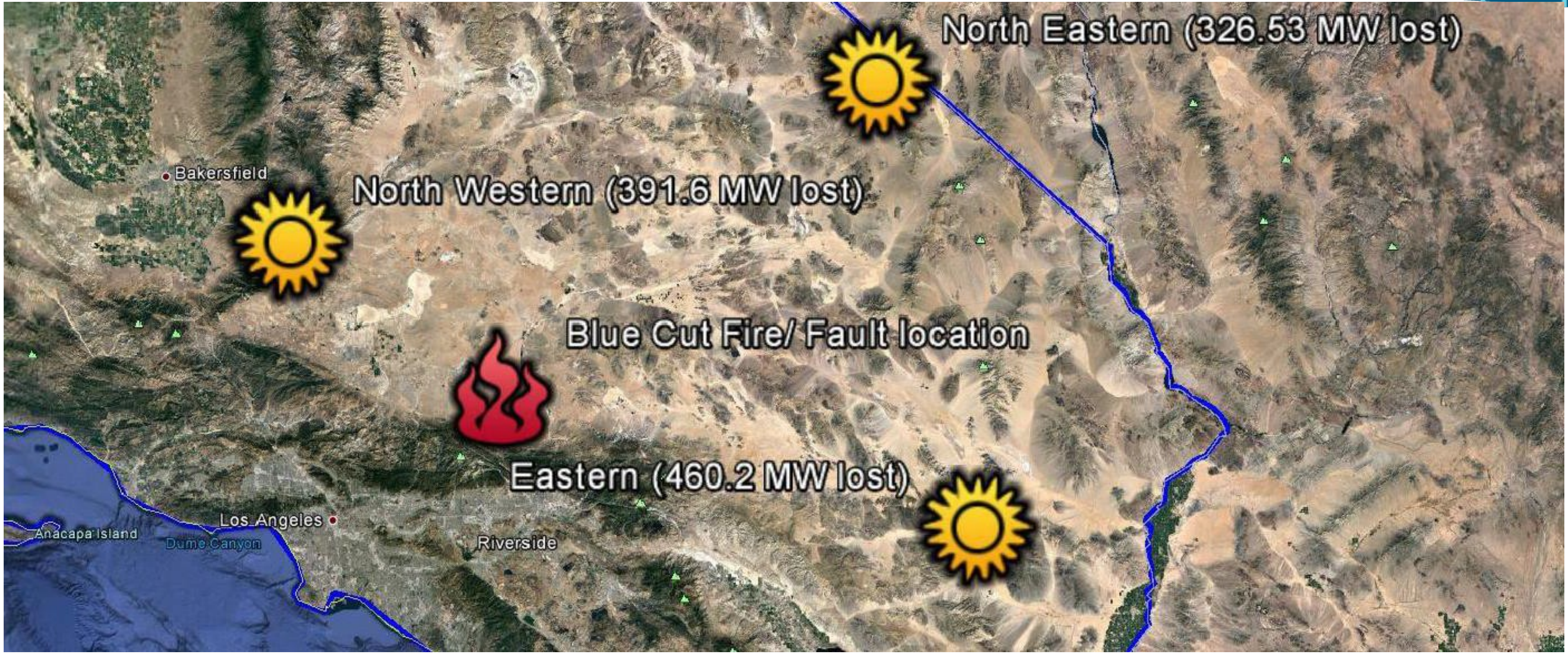
Blue Cut Fire on 16 August 2016 Faults

Blue Cut fire caused

- Thirteen 500 kV line faults
- Two 287 kV line faults

At 11:45:06 PDT Fault

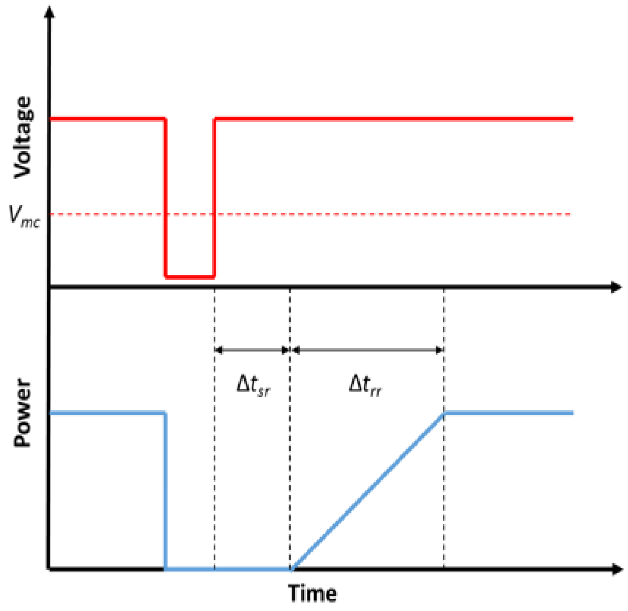
- 500 kV line-to-line fault
- Cleared normally in 2.5 cycles (41.7 milliseconds)
- PV resources impacted – 1,178 MW
  - 26 different solar developments
  - All utility scale – connected at 500kV or 230kV
  - 10 different inverter manufacturers
  - No PV site system protection relays/breakers operated
  - All action was by on-board inverter controls



Fault				Maximum Generation Lost (MW)			
Event #	Time	Fault Type	Fault Duration (cycles)	North Western	North Eastern	Eastern	Total
1	11:45	Line to Line	2.49	391.6	326.53	460.2	1178.33

Modes of Operation

- Inverters have three modes of operation:
  - **Continuous Operation:** injecting current into the grid
  - **Trip:** cease injecting current, disconnect from grid, wait ~5 minutes, automatically return to service if voltage and frequency are within bounds
  - **Momentary Cessation:** momentarily cease injecting current during voltages outside continuous operating range – 0.9 to 1.2 pu
    - **Momentary cessation is an inverter operating state where the power electronic "firing commands" are blocked such that both active and reactive current go to zero output.**



Source: https://www.nerc.com/comm/PC/NERCModelingNotifications/Modeling_Notification_-_Modeling_Momentary_Cessation_-_2018-02-27.pdf

Key Findings

- Largest solar PV loss (~700 MW) due to underfrequency tripping
  - Inverter sensed near instantaneous frequency of < 57 Hz and tripped
  - Solar development owner and inverter manufacturer interpreted outside of the PRC-024-2 no-trip curve area as a must-trip area
  - Frequency table in PRC-024-2 for the Western Interconnection indicates instantaneous trip for frequency equal to or less than 57 Hz.

- Momentary Cessation Due to Low Voltage
  - Majority of currently installed inverters are configured to momentarily cease active current injection for voltages above 1.1 per unit or below 0.9 per

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Blue Cut Fire Recommendations

- Added time delay to inverter under-frequency tripping to mitigate erroneous frequency tripping
  - Allows inverter to “ride through” transient/distorted waveform period without tripping
- Clarify that outside the PRC-024 frequency and voltage ride- through curves are may trip, not must trip
- Review PRC-024 to determine if any changes are needed
- Further study needed for risk associated with momentary cessation (IRPTF)
- Issue industry Alert to inform and collect information from industry on exposure

Canyon 2 Event on 9 October 2017

Source: https://www.nerc.com/pa/rrm/ea/October%209%202017%20Canyon%202%20Fire%20Disturbance%20Report/900%20MW%20Solar%20Photovoltaic%20Resource%20Interruption%20Disturbance%20Report.pdf

Canyon 2 Event on 9 October 2017

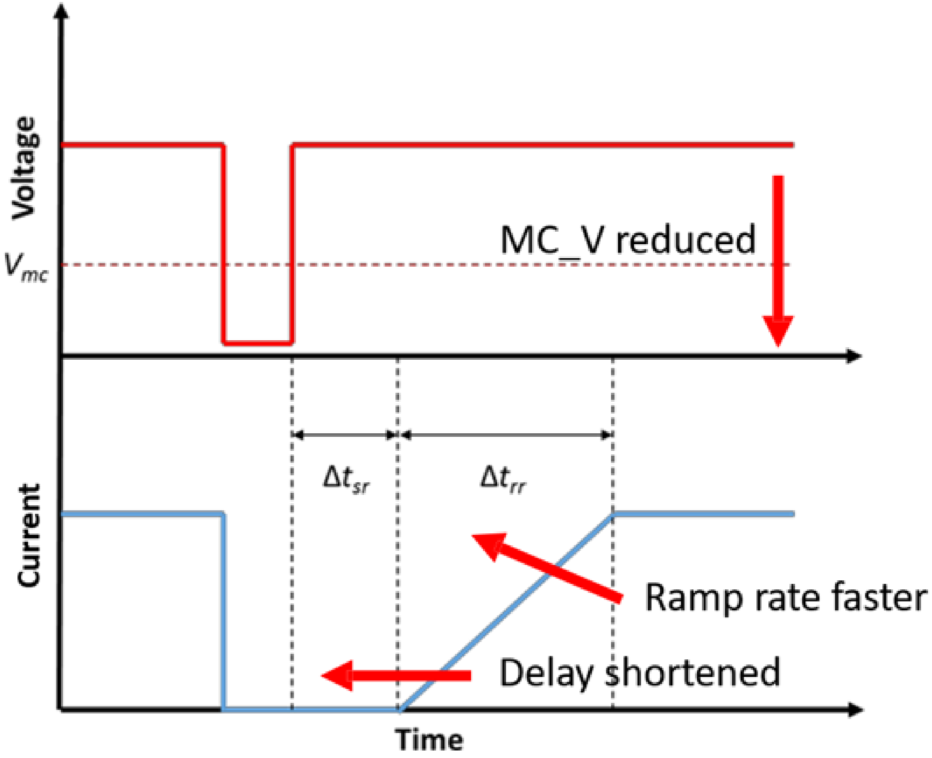
Key Findings

- No erroneous frequency tripping
  - Actions from first Level 2 Alert appear to have mitigated identified issue
  - By the Canyon 2 Fire disturbance, 97% of manufacturer's BPS-connected fleet had been updated

- Continued use of momentary cessation
  - Most inverters use momentary cessation (V < 0.9 pu)
  - Recovery following momentary cessation varies, relatively slow for grid dynamics
  - Updated recommendation for momentary cessation – **eliminate the use of momentary cessation to the greatest extent possible**

- Transient overvoltage tripping and application of the PRC-024-2 ride-through curve

Momentary Cessation Recommendations



IEEE Announcement on New Standard for Inverter-Based Resources connected with Transmission Systems

- Recent events in North America such as the Blue Cut Fire Disturbance as well as institutional challenges in North America suggest the inappropriate use of IEEE Standard1547 for large-scale solar plants underscore this need

- Proposed new standard fulfills this need and can help equipment manufacturers, project developers, transmission planners, and power grid operators improve the quality of the inverter and facility performance to enhance the stability of the power grid

- NYISO is participating in this standard development process

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NERC Standards and Guidelines

- **NERC Reliability Guideline “BPS-Connected Inverter-Based Resource Performance ” September 2018**
  - Provides recommended steady-state and dynamic performance characteristics for inverter-based resources and also covers a wide range of related aspects from protective functions to monitoring capability

NERC SPIDERWG

(System Planning Impacts from Distribute Energy Resources Working Group)

- **Purpose**
  - To address impacts of DER on the Bulk Power System
- **Primary Focus**
  - DER data collection, modeling practices, model improvements, and steady-state and dynamic simulation assessments
- **Secondary focus on**
  - Assessing impacts to BPS essential reliability services (ERS), load forecasting, and other considerations that develop as the industry assesses the increasing influences of DER on the BPS

- NYISO is participating in this Working group

Questions?

We are here to help. Let us know if we can add anything.

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The Mission of the New York Independent System Operator, in collaboration with its stakeholders, is to serve the public interest and provide benefits to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the bulk power system

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