Use cases for the Self-healing Grid

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Active Distribution Networks (ADN)

High penetration of:

- Load dependent on
  - Real-time pricing
  - Embedded DER
  - Demand Response
  - PEV
  - Technology
  - Other
- Large DER/ES/MG dependent on
  - Weather
  - Technology
  - Maintenance
  - Price
  - Volt/var control mode and settings
  - Protection settings

- Load Shedding Remedial Action Schemes dependent on
  - Operations of MG (connected – autonomous)
  - Load behavior (see above)
  - Overlapping with other schemes
  - Changing priorities
  - Pre-armed settings
- DMS applications dependent on
  - Objectives
  - Available tolerances
  - Available controls
Aggregated Load of ADN at the End-bus of Transmission Operations

- Significant deviations from conforming (typical, proportional) load shapes
- Significantly changing load-to-voltage dependences due to
  - Embedded DER
  - DER with Volt/Var control capabilities in different modes
  - DER/MG with voltage protection
  - Intermittent operations of DER
  - Changing combinations, mode of operations, and settings of voltage and var controlling devices
  - Demand Response with different PF
- Significantly changing load-to-frequency dependences due to
  - Embedded DER
  - DER/MG with frequency protection
  - Intermittent operations of DER
  - Changing number of DER on-line
  - Different frequency control capabilities

- Short-term predictability (minutes)
Architecturally Critical Information Exchanges for the SHG

• SCADA data
• PMU data
• Data on the behavior of Active Distribution Networks under normal and emergency conditions
Aggregation of Information on ADN in Transmission Bus Load Model (TBLM)

- Aggregated models of
  - Distributed Energy Resources and their behavior under normal and emergency conditions
- Controllable and uncontrollable reactive power resources
- Demand Response and its behavior
- VVWO behavior
- PEV performance
- Aggregated MW and Mvar dependences on voltage
- Aggregated MW and Mvar dependences on frequency
- Dispatchable real and reactive loads via:
  - VVWO
  - Demand Response
  - DER control
  - Emergency Load Shedding
Example
Near-real-time analysis of potential islanding
Pre-arming of Islanding requires

• Prediction of real power balance in the potential island (frequency)
• Prediction of reactive power balance in the potential island (voltage)
  – Islands are formed to minimize the load-generation imbalance
• Prediction of the reaction of the Active Distribution Network (~ 20% of DER, Micro-grids, Demand Response, VVWO, etc.)

➤ Adaptive near-real-time analyses based on
  ➤ Transmission model update
  ➤ PMU data
  ➤ Reaction of the Active Distribution Network
Two-area load-rich potential island (before the separation)

Disconnected
UFLS, UVLS for Sub-Area 1

Connected
G11
G12
Pt-jQ

Area 1
DER1/MG

Load 1

VVWO
DR

Load 2

Area 2
DER2/MG

UFLS, UVLS for Sub-Area 2

Disconnected

Connected
Two-area load-rich island (after the separation)

Disconnected

Connected

G11
G12
Load 1

UFLS, UVLS for Sub-Area 1

DER1/MG

VWVO

DR

P-jQ

G21
G22
Load 2

UFLS, UVLS for Sub-Area 2

DER2 /MG

Disconnected

Connected
Questions to be answered by the analyses of potential islanding

• Is the load-generation imbalance manageable during the island situation?
  – Will DER separate due to frequency or voltage, or both – with or without load?
  – Will the weak tie be overloaded?
  – Is the load shedding sufficient, etc.?
  – Are the priorities of load shedding adequate?
  – How will the situation develop during prolong islanding?
  – What is the latency and the possible contribution of Demand Response and VVWO?
  – What is the risk (uncertainty) factor?

• What re-coordination of protection and RAS would be needed?
Questions to be answered by the analyses of restoration after islanding

• What is the expected cold-load pickup?
• What is the latency and possibilities of DER resynchronization?
• What should be the priorities of load restoration?

➢ The TBLM should contain information that is needed to answer these questions.
Information and control flows

Distribution domain

AMI
DER/ES/MG
DR
PEV
Load model Processor
Topology Processor
RAS
DSCADA

Subst. LTC, Shunts, SVC

TBLM Processor

TBLM

T&G domains

PMU

EMS
SE
CA
SCD
Pre-arm Restoration

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RAS

DSCADA

Data
Control

T&G devices

Processor

Topology model

Processor

Topology model

Processor

Topology model

Processor

Topology model

Processor

Topology model
Priority Use Cases for Operations of SHG, addressing the cross-cutting over domains

- Creation and updates of Transmission Bus Load Model
- State Estimation
- Contingency Analyses with prioritization based on PMU and TBLM
- Security Constrained Dispatch – for preventive measures
- Pre-arming of Corrective Measures
- Restoration after emergency

Need to use PMU and TBLM
Thank you!