Grid Transformation Workshop

Damir Novosel

President, Quanta Technology
Probabilistic Planning – What to Include?

• Accurate modeling, including model and data exchanges across interconnection
• Incorporating operational experiences
• Infrastructure correlation and priorities
  o Gas – Electric interaction
  o Telecom – Electric
  o Aging assets and Storm hardening
  o Critical substations
  o Cyber security
  o SIPS management
  o EV and Storage
  o ...

Source: PJM
Defense in Depth Approach

- **Primary**: Reliability starts with good planning
  ... But actual system conditions are often different from what is planned ...

- **Secondary**: State estimator based real time contingency analysis
  ... But, your model may be wrong (model errors, control failures, etc) ...

- **Tertiary**: Intrinsic indicators > operating alarms and safety nets
  - Safety nets designed to protect against extreme unplanned events or FIDVR-type events when model is not certain
  - Could be viewed as a liability (poorly designed scheme can cause unnecessary loss of load, NERC CIP paperwork, etc)
  - What is the place for safety nets?

- **Wide Area Monitoring, Protection, and Control Vision**

Source: Dmitry Kosterev, BPA
Experiences with SIPS

Global Participants

- 64% in Asia
- 15% in Europe
- 9% in North America
- 6% in South America
- 3% in Australia
- 3% in Africa

To provide protective actions against (140 Entries)

- i. Congestion 10%
- ii. Small Disturbance Angle Instability 10%
- iii. Transient Instability 21%
- iv. Frequency Instability 17%
- v. Voltage Instability 26%
- vi. Thermal Overloading 16%
PMU Deployment

U.S. and Canada 2012

Source: NASPI
Wide Area Controls Vision

**Actions**

Conventional:
- Drop generation
- Drop load
- Reactive switching
- Schedule adjustment

New:
- Selective end-use drop
- Control of power flows

**Measurements**

Conventional:
- Transmission SCADA
- Line Status

New:
- Wide-area synch. measurements
- Load end-use measurements

**Decisions**

Convert data into information

New:
- Wide-area system state assessment

Source: Dmitry Kosterev, BPA
WAMPAC Progression

Before

First PMU

Now

Standard feature
(relays, DFR, controllers, equipment monitors)
On major interconnections
Some distribution PMUs
Improved communication & infrastructure, including control
Standard SW tools included in EMS/SCADA
Interoperability standards deployed

2014

2018

Thousands of PMUs world-wide
Higher data rates
Fully in Distribution
Fast Adaptive Protection
Integrated in standard business and operational practices
Distributed comm. architecture, fully-integrated with EMS/SCADA
NASPI/DOE/PIER Roadmap

- Angle/Frequency Monitoring
- Post-mortem Analysis (Including Compliance Monitoring)
- Voltage Stability Monitoring
- Thermal Overload Monitoring
- Improved State Estimation
- Steady-state Model Benchmarking
- DG/IPP Applications
- Power System Restoration
- Congestion Management
- Dynamic Model Benchmarking
- Planned Power System Separation
- State Estimation (Boundary Conditions)

Reflect the Value of Phasor Measurements
- Necessary and Critical
- Critical with Added Benefits
- Moderate Need, Added Benefits
- Requires More Investigation

Deployment Challenge
- LOW
- MED
- HI

1 to 3 Years
3 to 5 Years
> 5 Years
Voltage Instability: Short- and Long- Term

Fault Induced Delayed Voltage Recovery (FIDVR)

Voltage collapse

Long-term instability (low proportion of motors in local load)

Short-term instability (high proportion of motors in local load)

overshoot (8.5%)

26 seconds

10%

22%

V (pu)

0 0.2 0.4 0.6 0.8 1

0 20 40 60 80 100
time (s)

V (pu)

0 0.2 0.4 0.6 0.8 1

1 1.1

110 120 130 140 150 160 170 180
time (s)
Voltage Stability Assessment

Model-based simulation tools:
- Voltage Stability Assessment (VSA) based on State Estimation contingency analysis
- Tracking the relative distance from voltage instability continually in real-time
  - Distance to the nose of the PV curve
  - State Estimation based stability boundary
- Sensitive to model accuracy and dynamic system changes

Measurement-based indicators:
- Monitor available reactive power levels (capacitor/reactor reserves, tap-changers)
- Singular Value Decomposition (SVD)/Sensitivity
- Distance of the load's apparent impedance to the Thevenin impedance – Real-time voltage instability prediction (VIP, REI, VIP Improved/RVII)

Source: ABB

Source: BPA