Determination of Optimal Reserve with Consideration of Variable Generation and Controllable Loads

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FERC Technical Conference
Washington, DC
June 29, 2011
Outline

• Introduction
• Stochastic OPF
• Project Contributions
  – Modeling Enhancements
  – Three Applications
• Project Report
Introduction

Industry Issues
- Reliable dispatch for high levels from variable generation (VG)
- Determining daily/hourly reserve
- Assessing operational risks
- Evaluating reliability under stressful conditions

P173.004 2010 Project Goals
- Examine various risk measures
- Multiple sources of uncertainty
- Ramping needs and constraints
- Application focus

Deliverable
- Technical Report

Many Enhancements and Applications
Stochastic OPF

- High wind penetration makes a difference between deterministic and stochastic

**Deterministic**
- Cost = 11,026
- LOLE = 0.134

**Stochastic**
- Cost = 12,599
- LOLE = 0.290

Lower Cost
Higher Reliability
Stochastic OPF

- More energy and reserve
- More diversification

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<th>Energy</th>
<th>Reserve</th>
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<td>G4</td>
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<td>G5</td>
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<td>Total</td>
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Wind Variation at G5
20 MW to 60 MW

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<tr>
<td>G4</td>
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<td>G5</td>
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<tr>
<td>Total</td>
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<td>150.4</td>
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Deterministic
Cost = 11026 13793
LOLE = 0.134 0.495

Stochastic
Cost = 12599
LOLE = 0.290

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Project Contributions
*Model Enhancements*

✓ Ramping Scarcity and Allocation
  – Ensure smooth, short-term operations

✓ Multiple Sources of Uncertainty
  – Better realism

✓ Reporting of Benefits and Risk Measures
  – Understand and quantify risks
  – Establish performance benchmarks
Example Enhancement for Ramping

- Ramping Scarcity and Allocation
  - Share ramp capability between energy ramping and reserve ramping
  - Sub-interval ramping means schedules will ramp
  - Implemented the multiple-stage optimal power flow problem with ramp-rate sharing and sub-interval deviation.
Example Enhancement for Ramping

- IEEE 9-Bus Network
- Uncertain Wind at Bus 5
- Contingencies at G1, G2, and G3

Without Ramping Allocation
Cost = 10448

With Ramping Allocation
Cost = 10536
Project Contributions

Three Applications

✓ Reserve Determination Supports Operations Planning
  – Decide energy and reserve schedules
  – Estimate the expected costs for redispatch

✓ Reserve Validation Supports Operations Planning
  – Given energy and reserve schedules
  – Estimate the expected costs for redispatch
  – Estimate risk levels

✓ Rapid Redispatch Supports System Operations
  – Given a sampling of redispatch scenarios
  – An actual event takes place
  – Rapidly compute a optimal or near-optimal re-dispatch
Example Rapid Redispatch

• Precomputed Redispatch Solutions
  – A, B, C, D, E

• Compute New Redispatch
  – P
  – Combination of closest points: A, E, D

• Simple Formulation Allows for Added Features
  – Limit Number and Location of Control Operations
Project Report

Product 1020501
*Technique for Reserve Determination with Consideration for Conventional and Emerging Technologies*

- Describes all enhancements
- Examples for all applications
- Appendices contain all GAMS code
- *Available now!*
Questions & Discussion
Together…Shaping the Future of Electricity
Appendix
Enhancement for Risk Measures

✓ Reporting Benefits and Risk Measures

– New estimates for measuring benefits and risk
  • Loss of Load Expectation
  • Expected Unserved Energy
  • System Reserve Margin
  • Duration and Frequency of Outages