Risk Limiting Dispatch

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Outline

• EPRI PRISM 2.0 Insights
• Examples of Uncertainty
• Dispatch Issues
• Enhanced Dispatch Vision
• Risk Limiting Dispatch
• Summary
• Discussion
Prism “Test Drive” Insights

Source: EPRI Prism 2.0 Study

- Efficiency and renewables grow
- Managed transition for existing coal fleet

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What We Are Seeing…

• Response to emission regulations, renewables, and natural gas discoveries
  – Coal retirements offset by new renewables
  – New natural gas plants

• Renewable integration impacts
  – More balancing resources
  – Thermal fleet cycling -> increased O&M

• In the long term
  – Nuclear and CCS will be important
  – Without them, we rely on more renewables & efficiency
Example of New Uncertainty

Could you predict the production for this wind park either day-ahead or 5 hours in advance?

Each Day is a different color.

Source: California ISO

Tehachapi Wind Generation in April – 2005
Typical Dispatch

Constraints
- Power balance
- Operating Limits
- Contingencies

Objective
- Min. cost
  s.t. feasible power flow

Uncertainties:
- Load Forecasting
- Forced outage of equipment
- Increasing amounts of wind and solar power

Source: Bialek, Varaiya, and Wu
Forecast Error vs. Forecast Horizon

Source: Iberdrola Renewables
Dispatch Dilemma System Operators

• Operators must reserve sufficient capacity to meet the worst-case uncertainty in supply
• Errors in day-ahead wind forecasts regarded as “uncertain”
• Intermittent power as statistically unpredictable
• The worst case scenario is full cut-off
• Planned wind expansion requires enhanced dispatch
Enhanced Dispatch Procedures Require

• Availability of sensors for more accurate prediction over shorter time periods

• Probabilistic forecasts for less familiar technologies:
  – Renewables
  – Plug-in Electric Vehicles
  – Demand Response

• Stochastic Optimization to enable reliability assessment and efficient scheduling
Risk-Limiting Dispatch Goals

Establish a framework for evaluating benefits of

- Multiple settlements
- Decreasing forecast errors

Modify dispatch procedures so that:

- Combine intermittent resources with storage, demand-management, Plug-in Electric Vehicles (PEVs)
- Operate the new portfolio just as reliably
- Manage the cost of reserves to support uncertainty
- Requires smart grid infrastructure for enhanced communication and control
Compare Multi-Settlement Strategies

- **2-settlements**: Transact only points 1 (DA) and 10 (RT)
- **10-settlements**: Transact at all 10 points

**Decreasing Forecast Error towards RT**

**Normalized Benefit of 10 vs. 2 Settlements**

\[
\frac{(2\text{-stage cost} - 10\text{-stage cost})}{10\text{-stage cost}}
\]
Increasing the Opportunities to Adjust

• System flexibility is the key attribute needed to respond to uncertainties
• The more opportunities system operators have to adjust supply and demand resources the greater the financial benefits
• The key is finding the optimal frequency and timing of resource adjustments
• Benefits can be quantified
• The frequency and timing of iterative adjustments be brought increasingly closer to the scenario arising from “perfect information"
Summary

• Current practice of worst-case dispatch requires subsidies for renewable sources and demand response
• Better wind forecasting
• More refined control suggest shift to risk-limiting dispatch
• Rapid coordination (both preventive and corrective) with demand response and energy storage
Questions & Discussion
Together…Shaping the Future of Electricity
Appendix
Scenarios: Timing

• All stages are only for buying 1 hour of energy.
• 4 Stage Market at day-ahead (24 hours), hour ahead, 15 min ahead and Real Time.
• 3 Stage Market at day ahead, hour ahead and real-time.
• Oracle scenario.
Scenarios: Cost

- Per MWh cost of 4 stages:
  - $52.00 (day ahead)
  - $60.00 (hour ahead)
  - $72.00 (15 minutes ahead)
  - $1000.00 (RT, “loss of load”)
Cost Comparison
Additional Cost of 3 stage over 4 stage

Maximum is $1.73 per MWh at D = 0.04 p.u.
Comparing Dispatch

- Understand how resources are used by comparing distributions of dispatch at each stage

- Consider $D = 0.04 \text{ p.u.}$ and $D = 0.5 \text{ p.u.}$

- Plot: % use in 30 years (for one hour) with respect to $D$ for 4 Stage vs. 3 Stage
Total Energy Contracted

\[ D = 0.04 \]

\[ D = 0.50 \]
Total Energy Contracted D=0.50
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