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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

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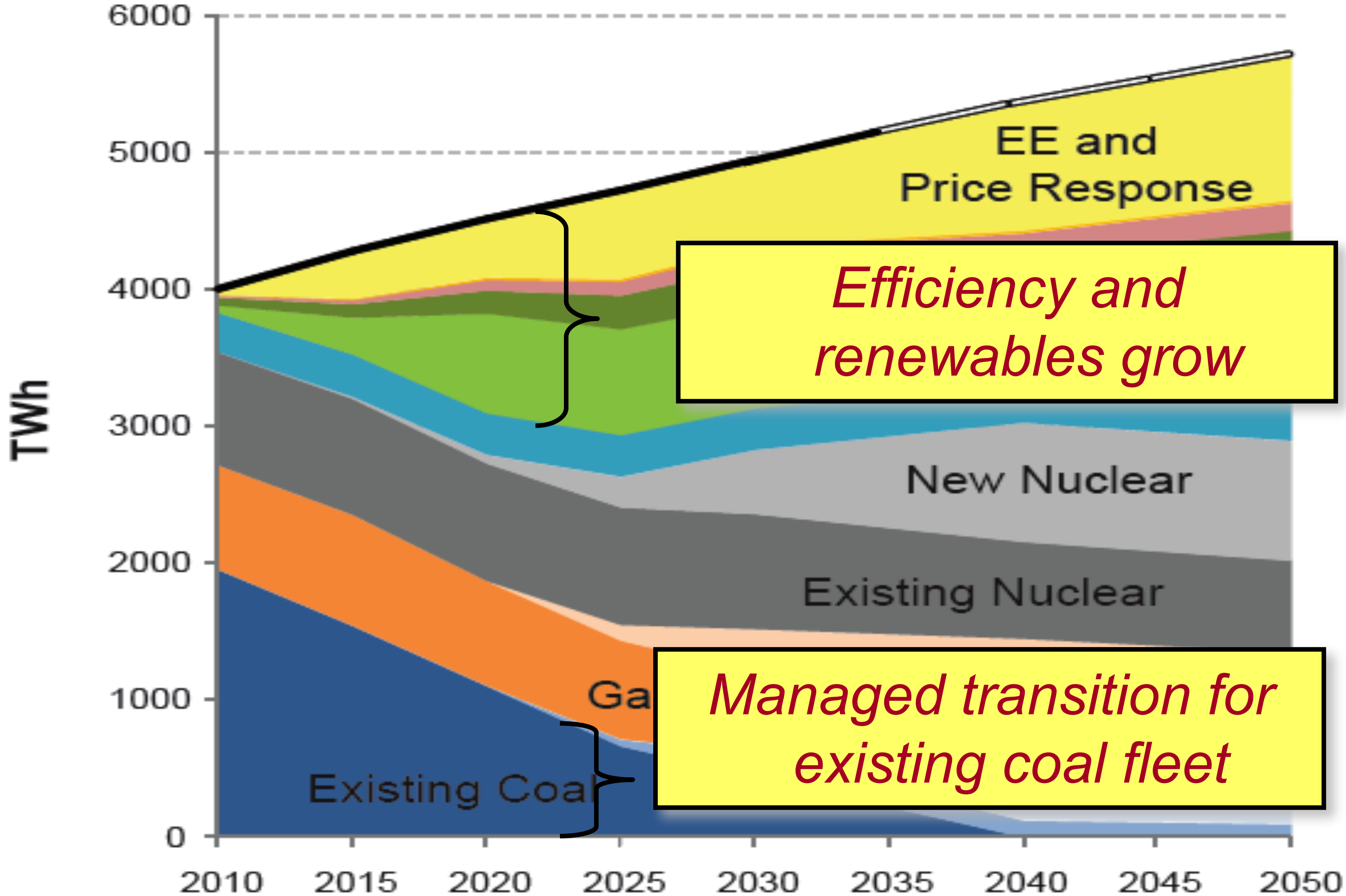
Prism "Test Drive" Insights



Source: EPRI Prism 2.0 Study

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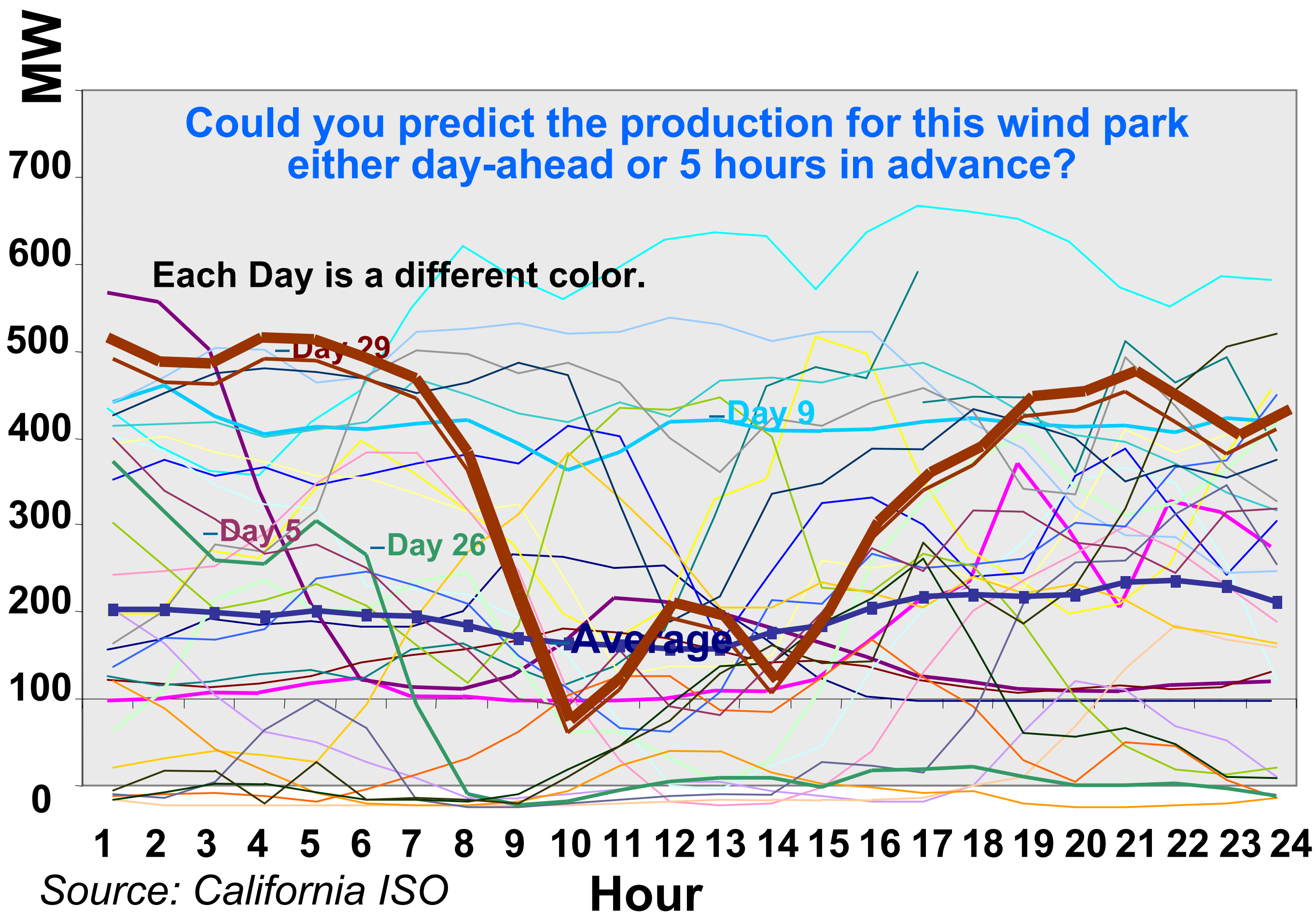
What We Are Seeing…

- 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

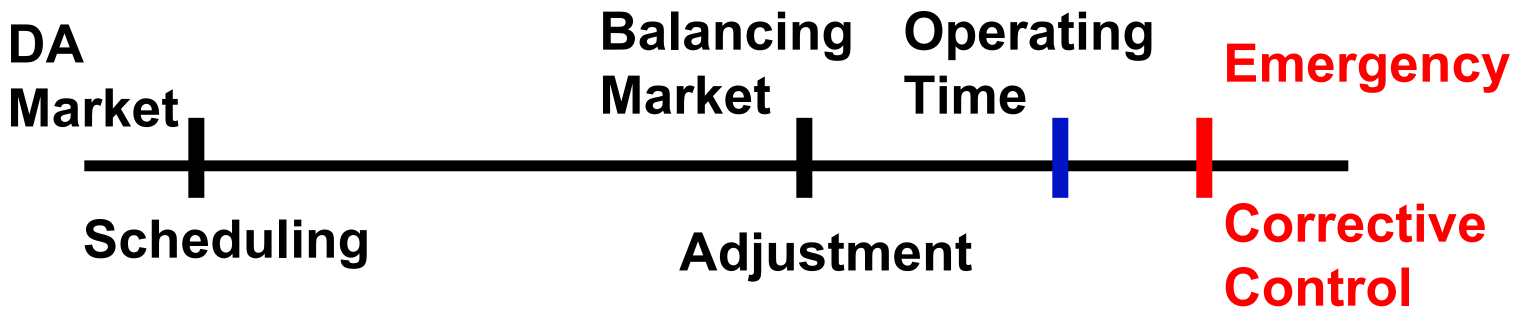
Example of New Uncertainty



Source: California ISO

Tehachapi Wind Generation in April – 2005

Typical Dispatch



Constraints

- Power balance
- Operating Limits
- Contingencies

Objective

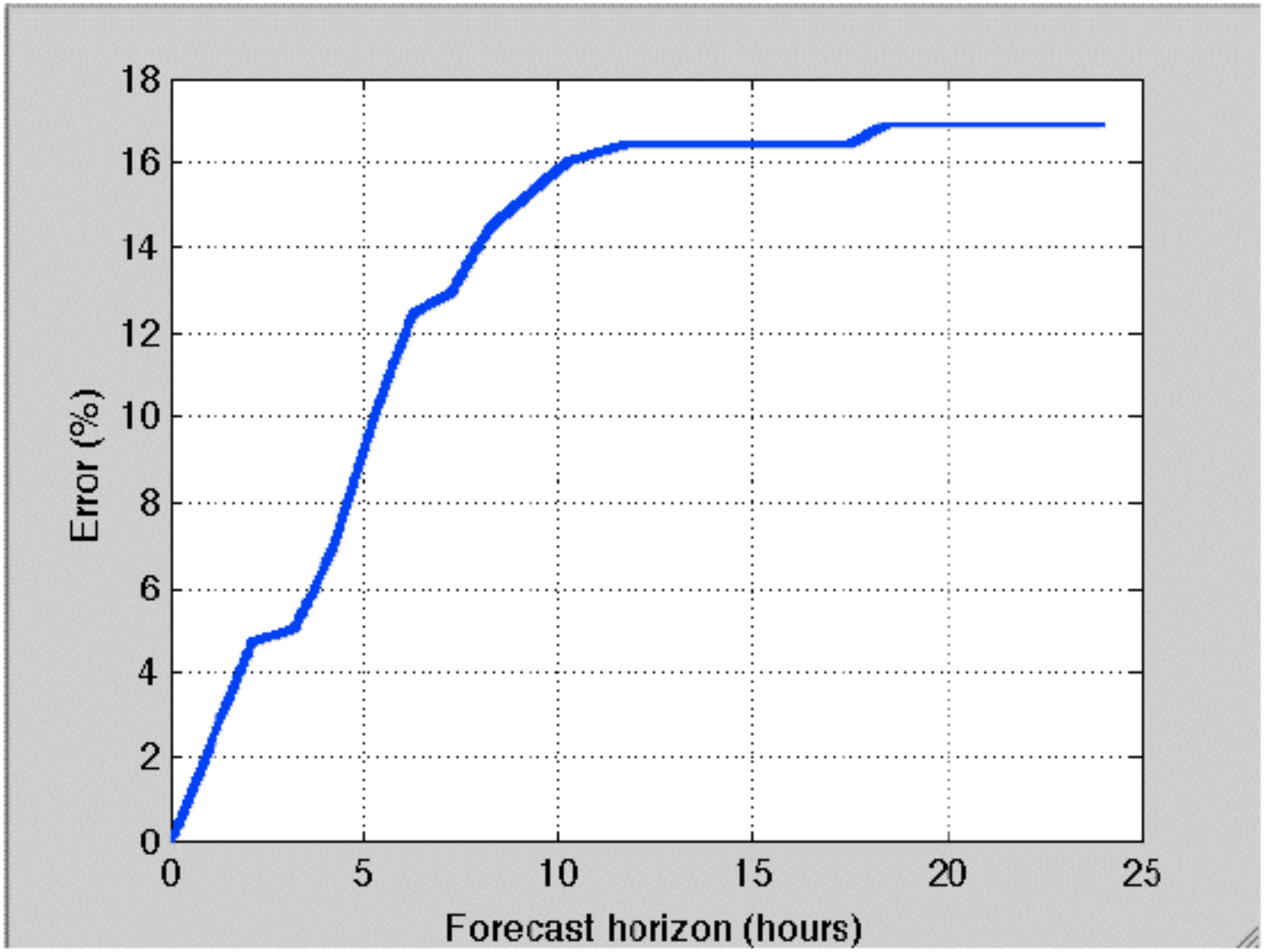
- Min. cost
  s.t. feasible power flow

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

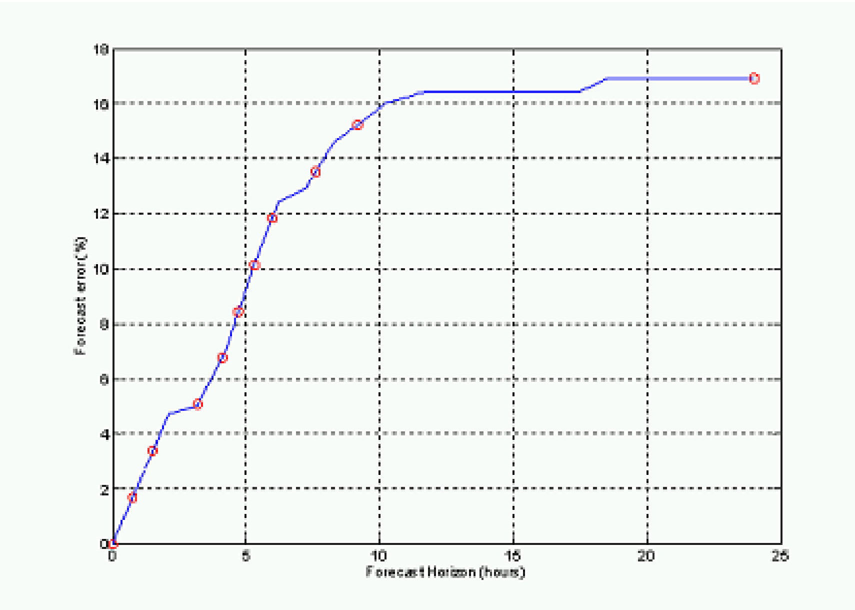
Risk-Limiting Dispatch
Goals

Establish a framework for evaluating benefits of
- Multiple settlements
- Decreasing forecast errors

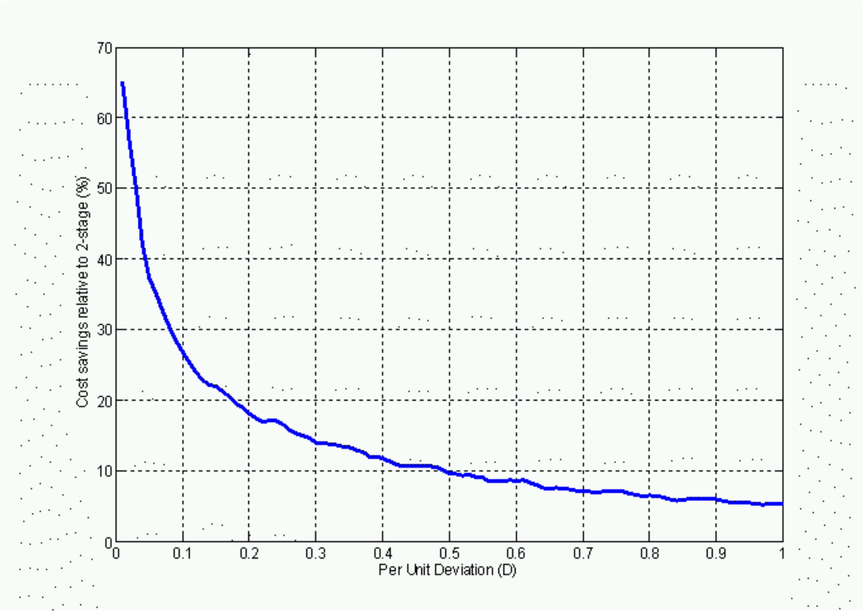
Modify dispatch procedures so that:
- Combine intermittent resources with storage, demand-management, Plug-in Electric Vehicles (PEVs)
- Operate the new portfolio just as reliably
- Manage the cost of reserves to support uncertainty
- Requires smart grid infrastructure for enhanced communication and control

Compare Multi-Settlement Strategies

Decreasing Forecast Error towards RT



Normalized Benefit of 10 vs. 2 Settlements



(2-stage cost – 10-stage cost)/10-stage cost

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

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

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Appendix

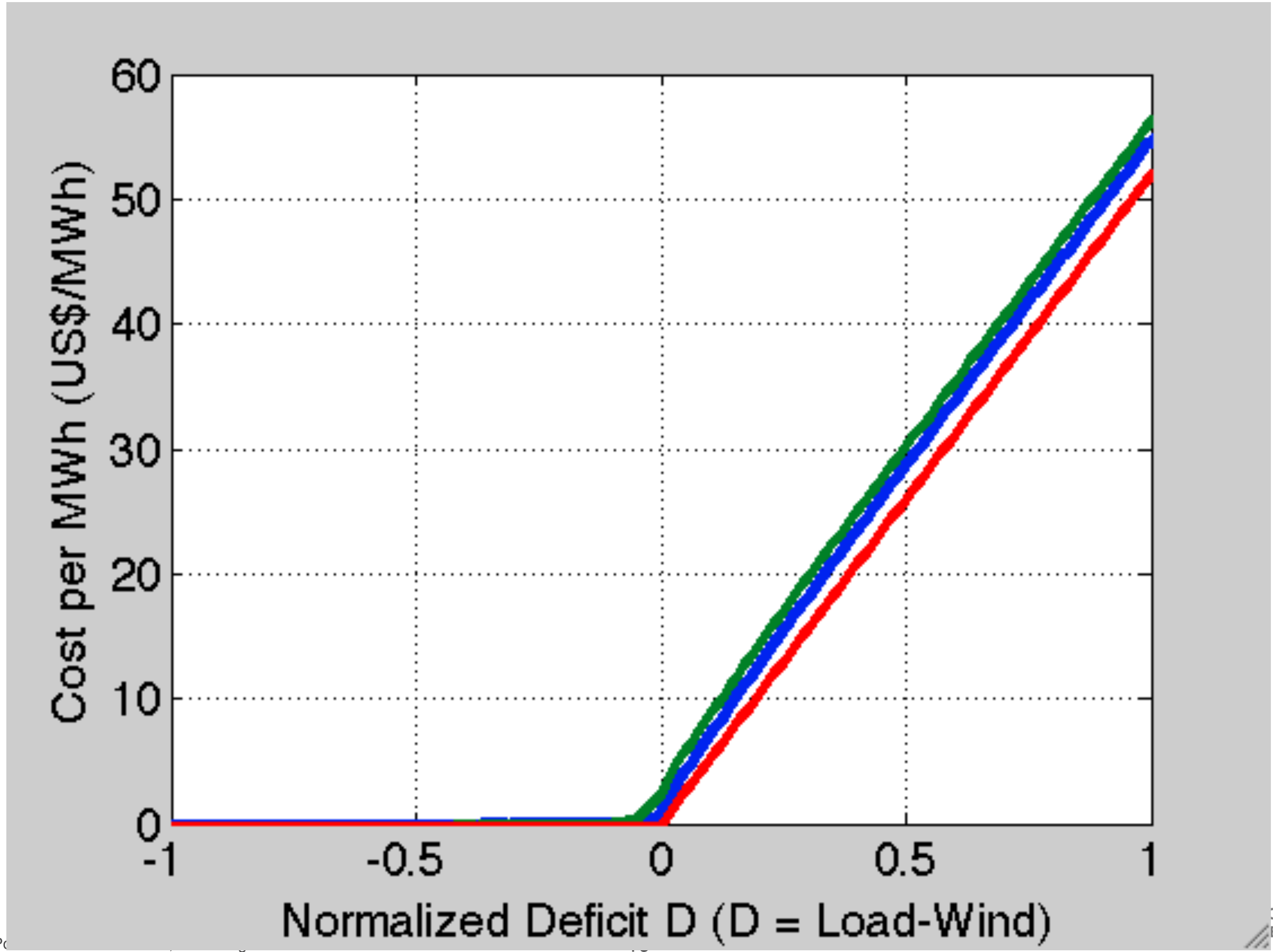
Scenarios: Timing

- 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.

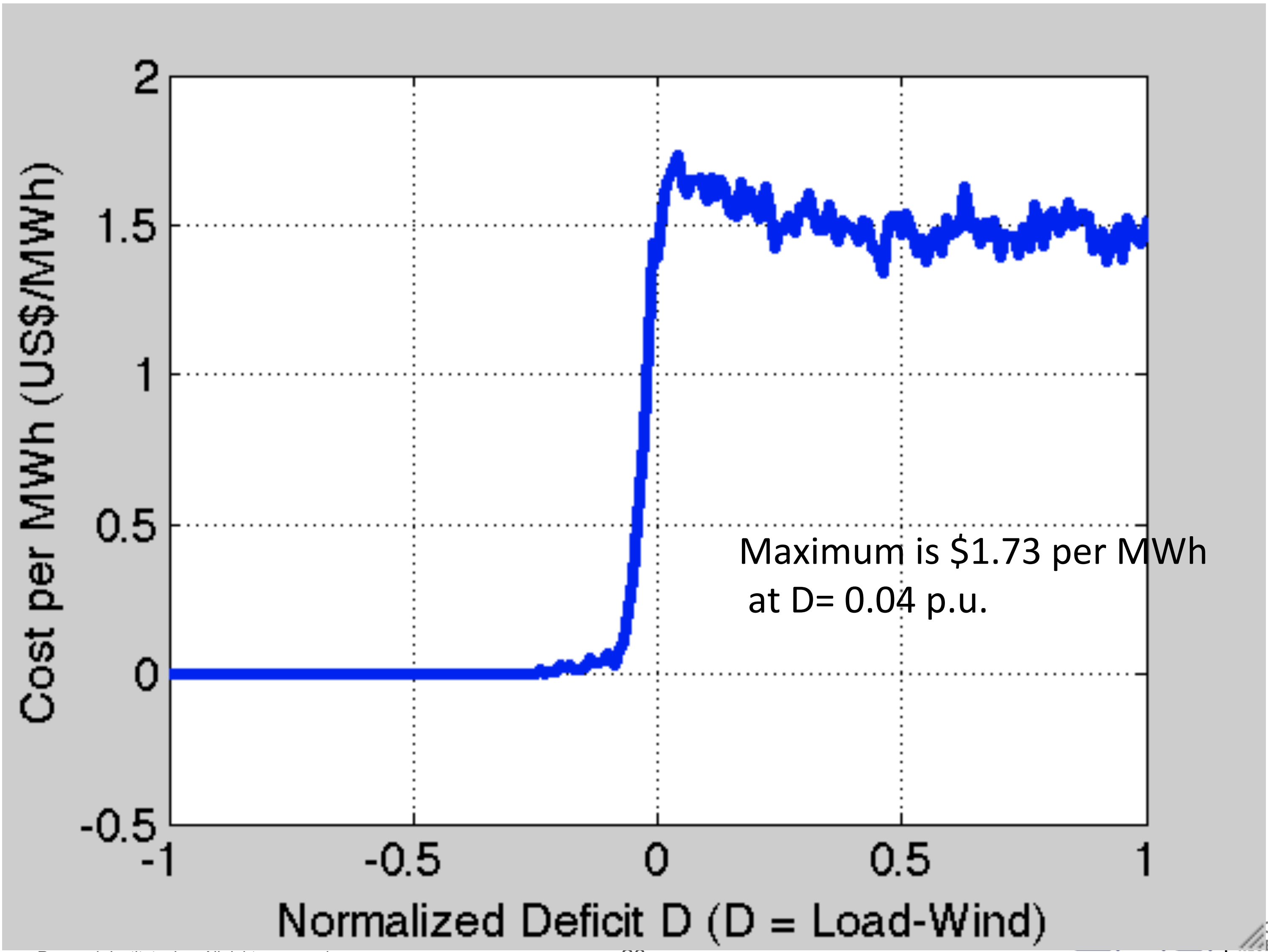
Scenarios: Cost

- 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



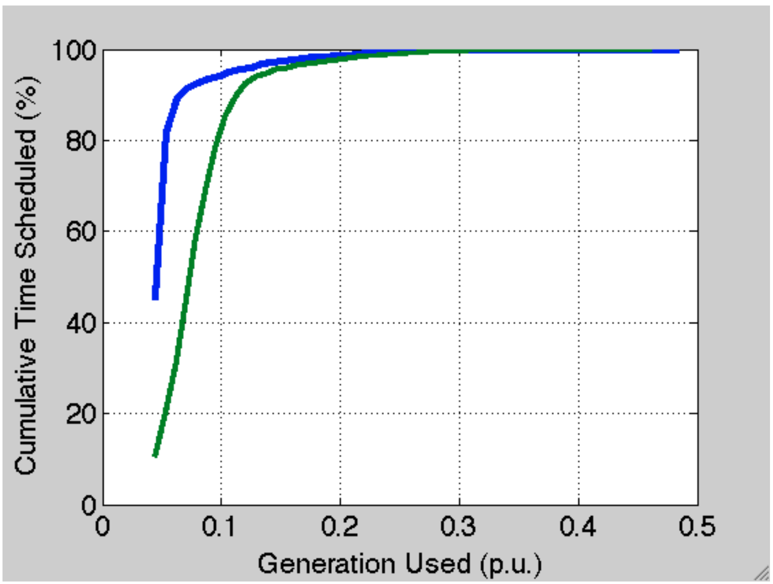
Additional Cost of 3 stage over 4 stage



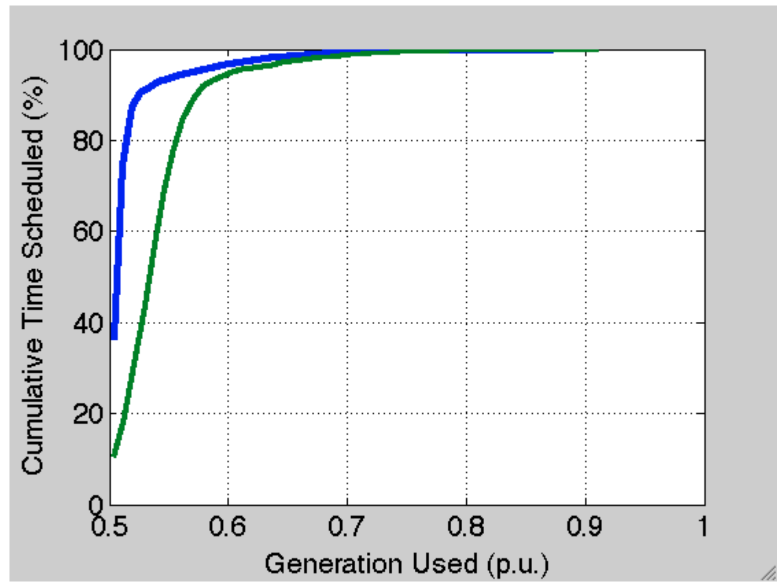
Comparing Dispatch

- Understand how resources are used by comparing distributions of dispatch at each stage
- Consider D = 0.04 p.u. and D = 0.5 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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