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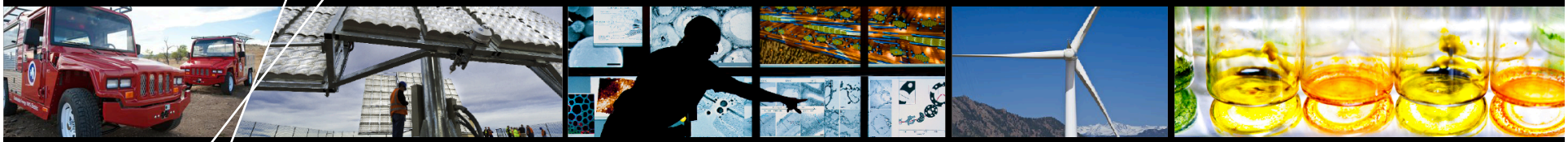
Western Wind and Solar Integration Study Phase 2 – Reserves



Results TRC Meeting

Eduardo Ibanez, Greg Brinkman

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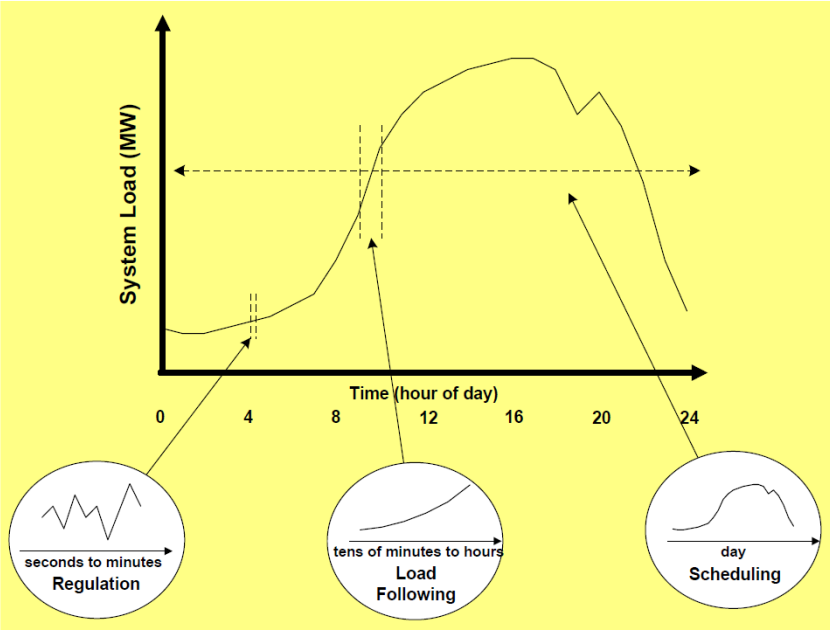
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Objective

- **Analyze wind and photovoltaic (PV) variability**
- **Develop a framework to create reserves that cover a significant level of the variability**
- **Method is applied to WWSIS2**
  - Different sensitivity runs to study effectivements

System Operation and Reserves



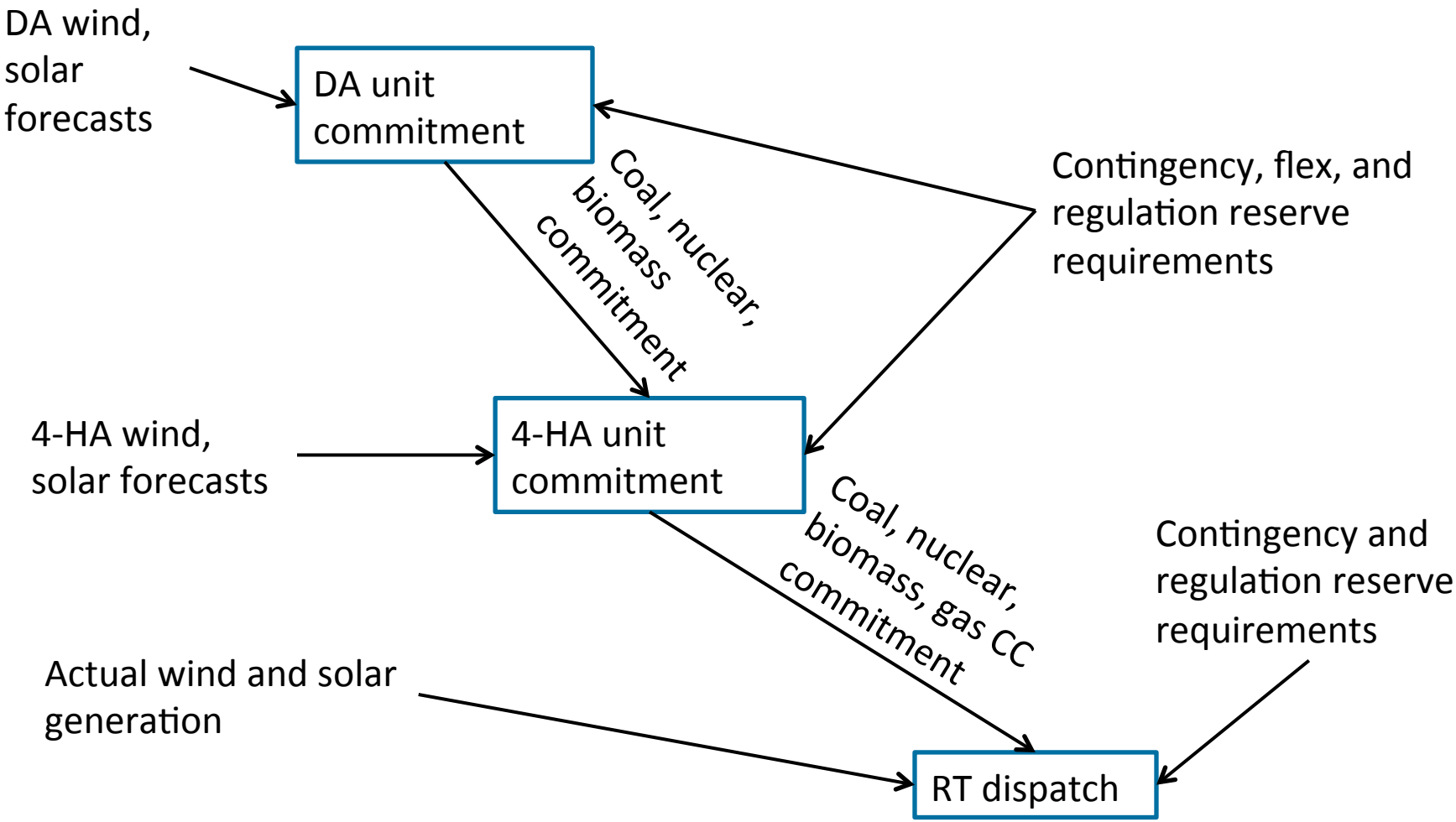
Operating reserves allow the system to respond to forecast errors and unexpected events

- **Contingency**
  - Events
- **Regulation reserves**
  - Second to minute variations
- **Flexible reserves**
  - Several minutes

Reserves in WWSIS2

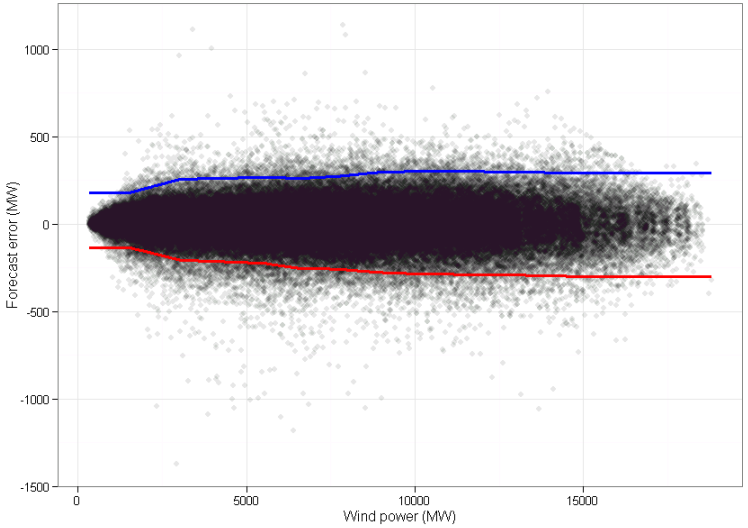
- **Contingency reserves**
  - 3% load (TEPPC)
- **Regulation reserves**
  - 1% load (TEPPC)
  - Renewable requirements added geometrically to cover 95% of 10-minute forecast errors
- **Flexible reserves**
  - No load contribution (lack of forecast)
  - Renewable requirements added geometrically to cover 70% of 1-hour forecast errors

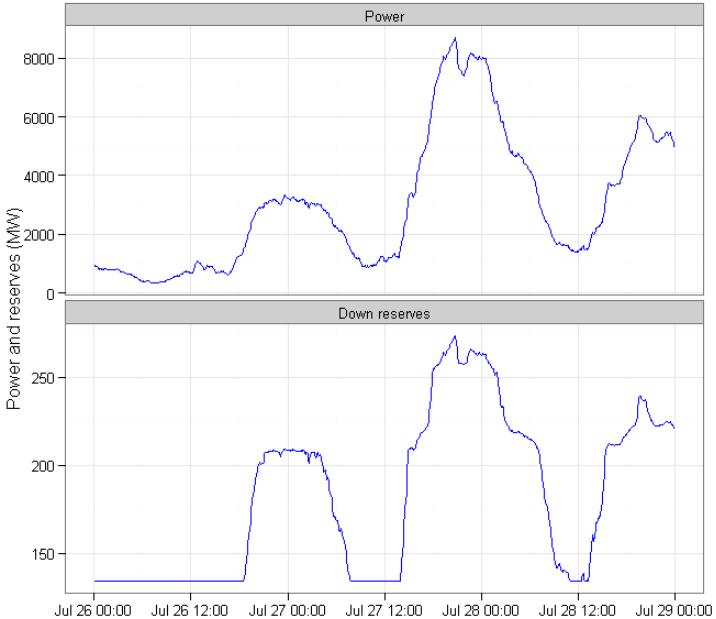
Market sequence



Wind Power Reserves

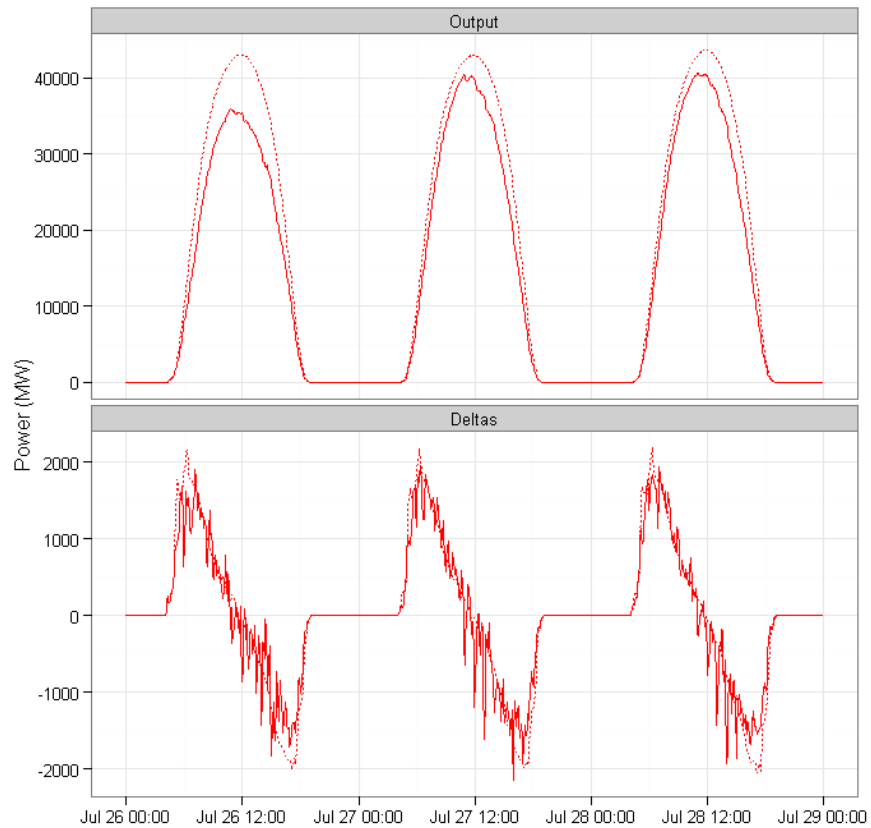
- **Short-term variations are hard to predict**
- **Forecast = Persistence forecast**
  - Error(t) = P(t+1) - P(t)
- **Variability changes with power output**
- **Example: Confidence intervals for contingency reserves**





Solar Reserve Methodology

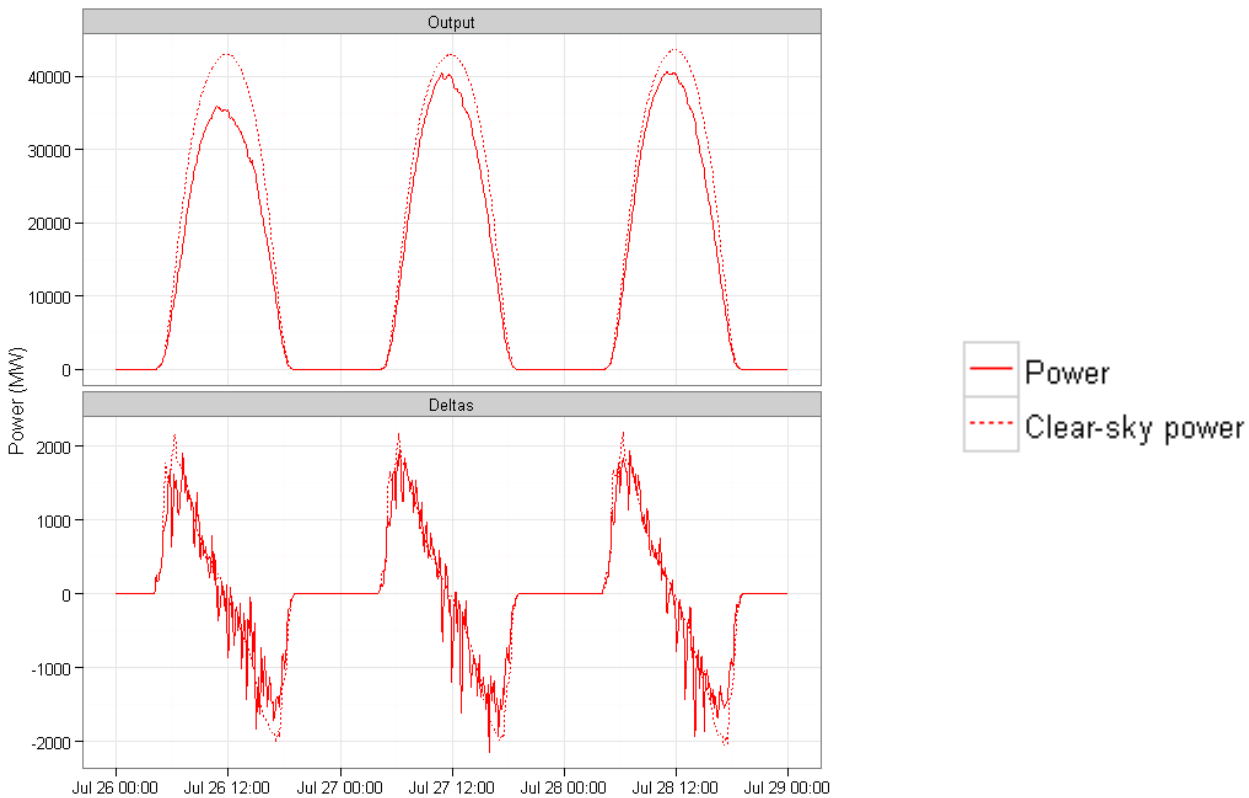
- **Based on wind power method**
- **Need to account for daily variations, which are known**
- **Steps:**
  a) Forecast error
  b) Explanatory variables
  c) Application



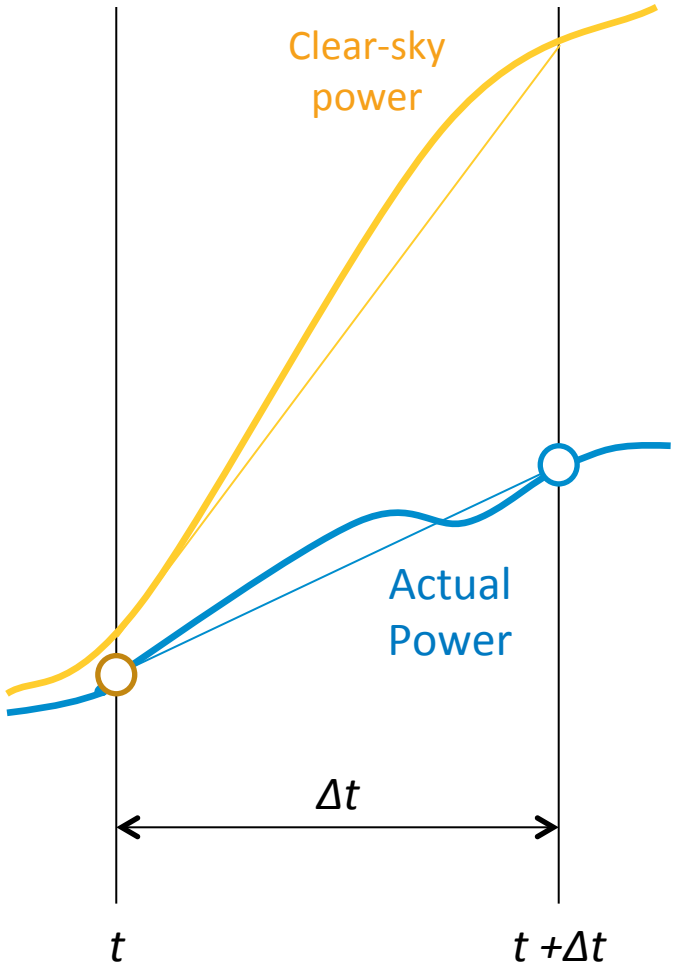
Solar Power Index (SPI)

- **Measures how close to clear-sky conditions**

SPI = Power / Clear-Sky Power

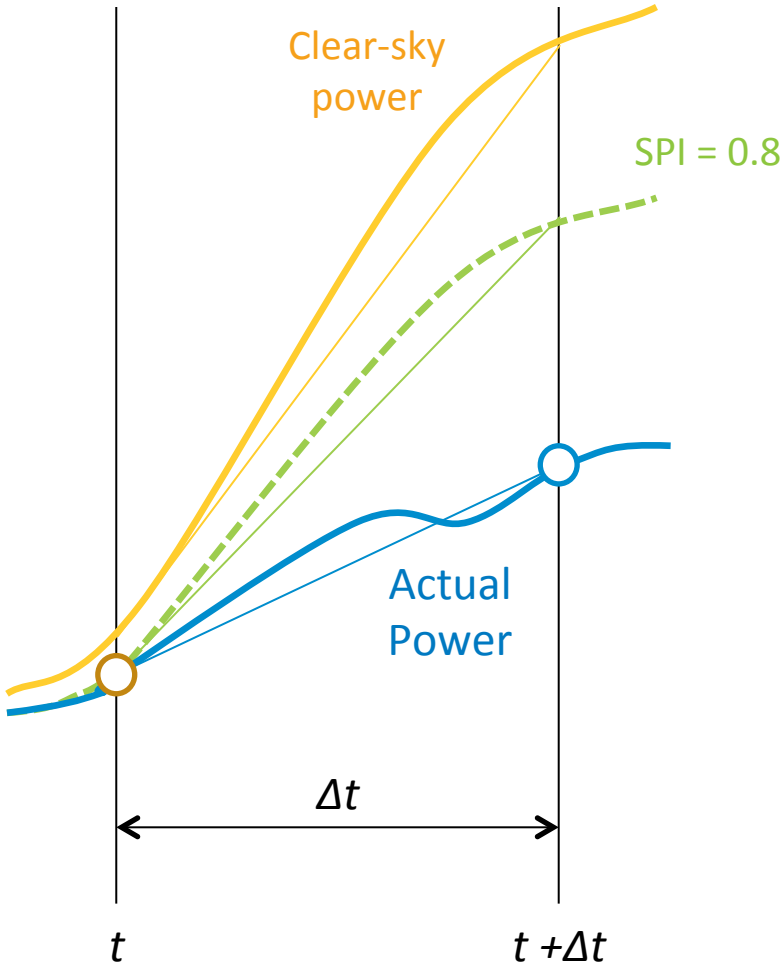


A) Forecast Error (I)



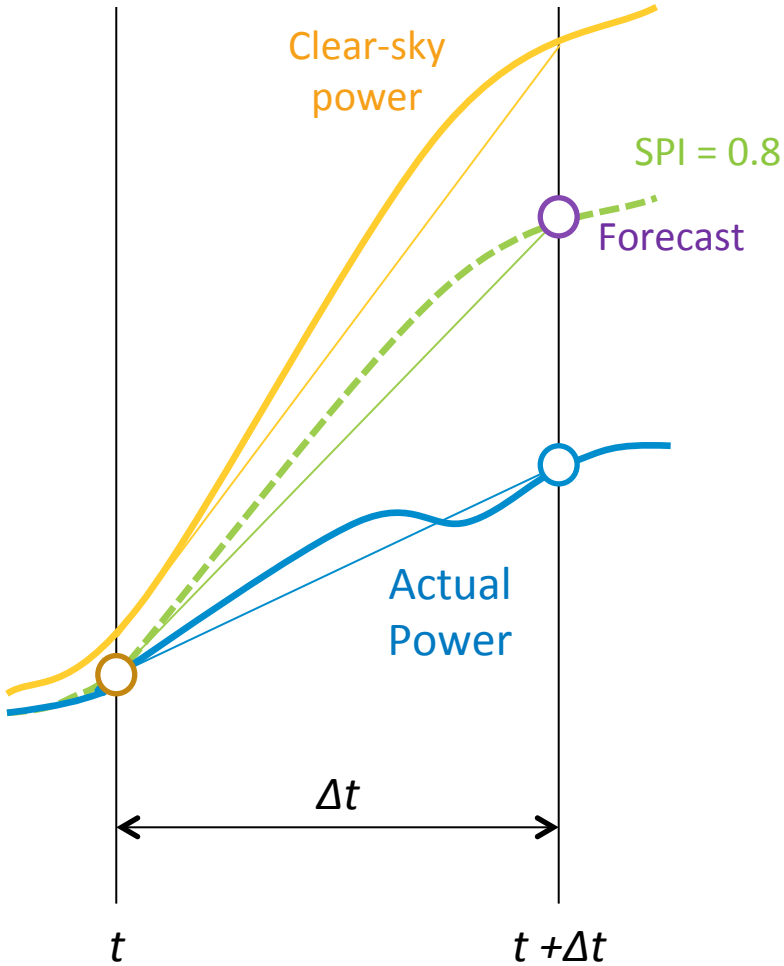
- **Consider time *t* and next time step, *t+Δt***

A) Forecast Error (II)



- **Consider time *t* and next time step, *t+Δt***
- **Assume constant SPI for forecast**

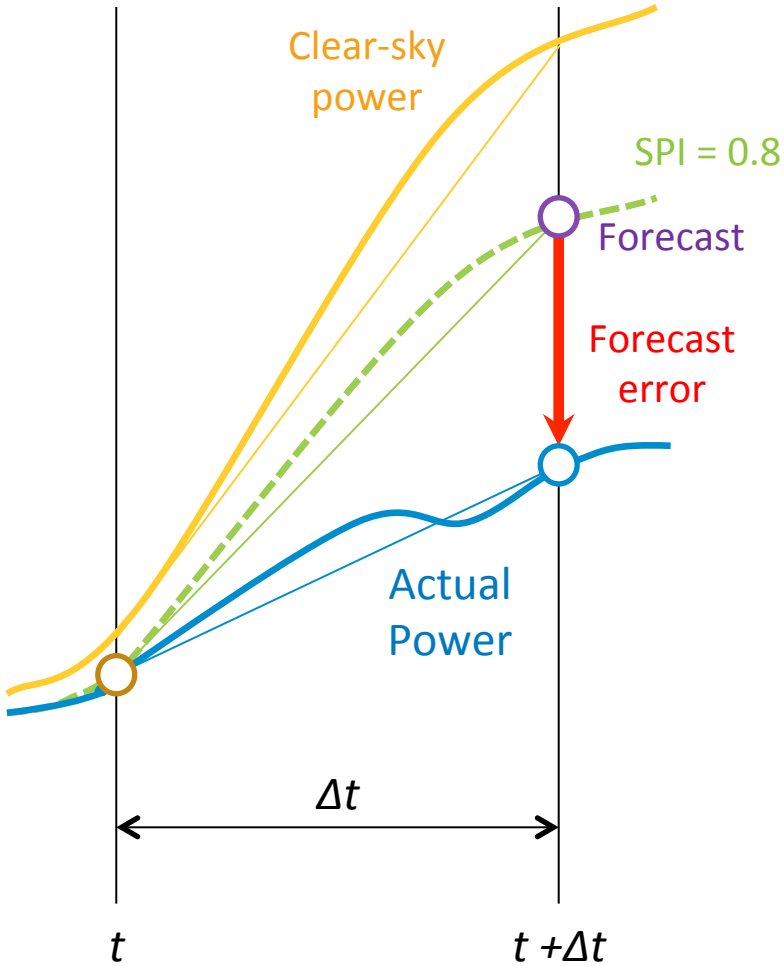
A) Forecast Error (III)



- **Consider time *t* and next time step, *t+Δt***
- **Assume constant SPI for forecast**

  Forecast = Power + SPI *ΔClear-Sky Power

A) Forecast Error (IV)



- **Consider time *t* and next time step, *t+Δt***
- **Assume constant SPI for forecast**

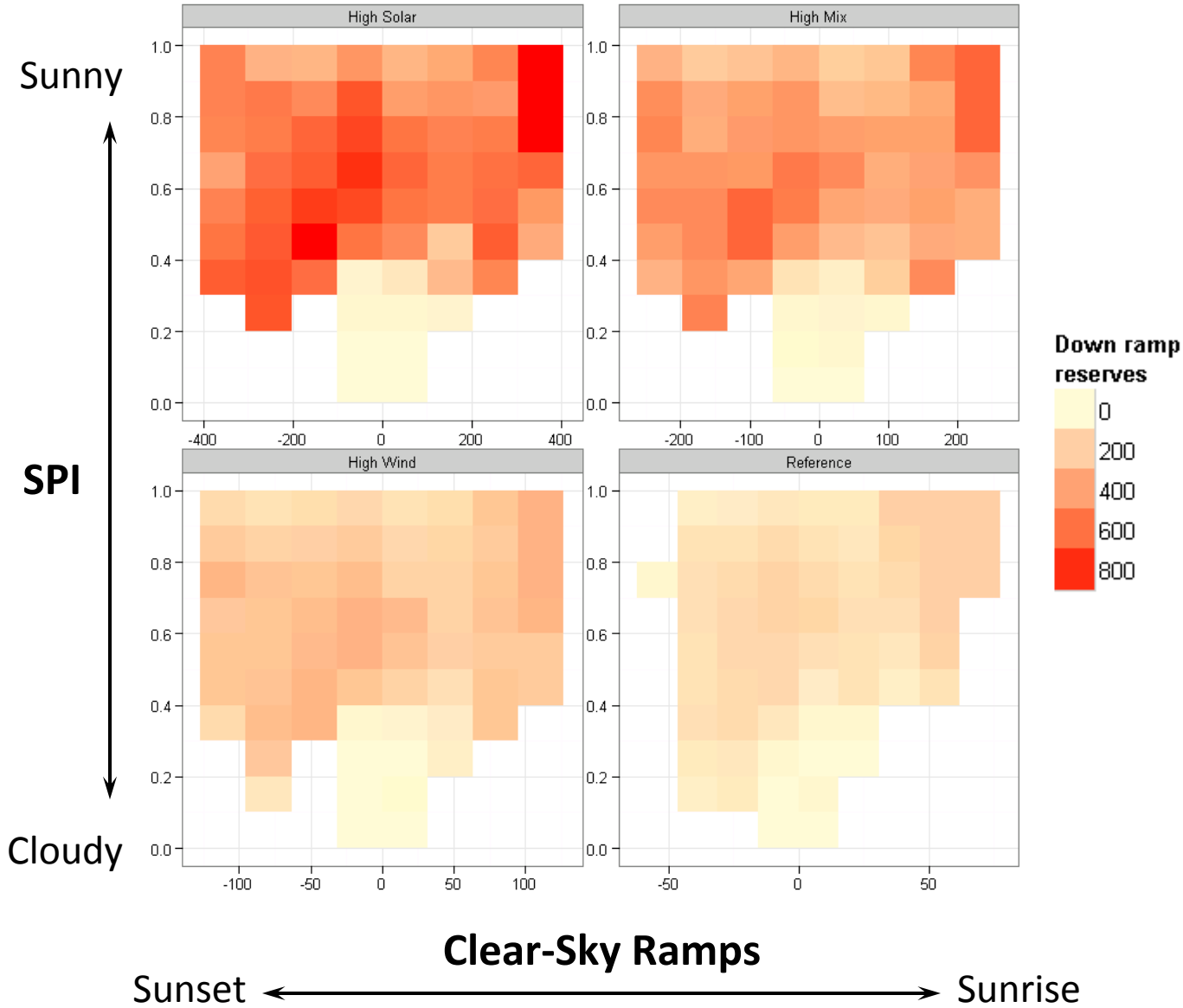
  Forecast = Power + SPI *ΔClear-Sky Power
- **Forecast error is the difference**

  Error = ΔPower + SPI *ΔClear-Sky Power

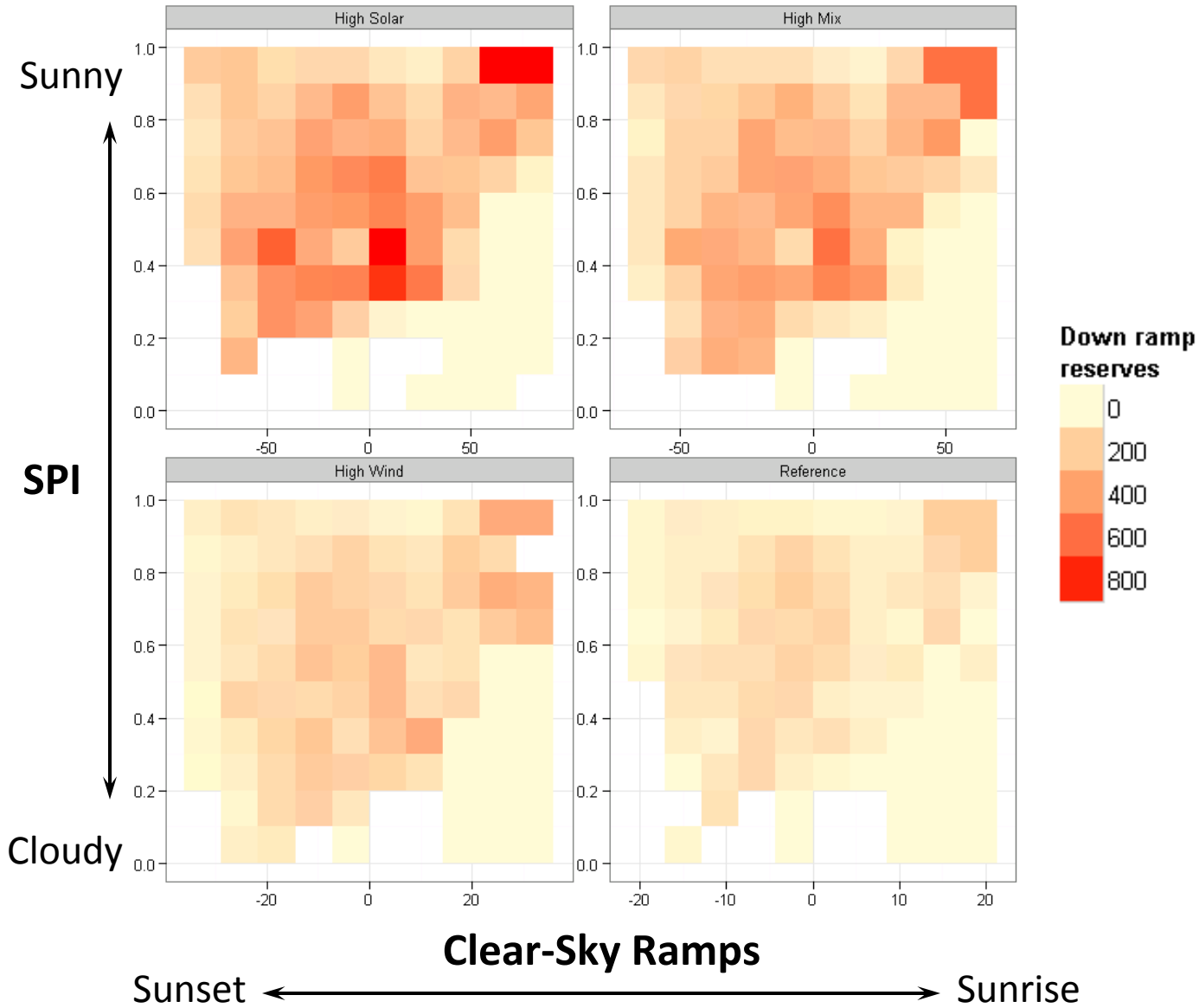
B) Explanatory Variables

- **Explanatory variables create groups of events that are similar**
- **Two variables:**
  - SPI: separates "cloudy" and "sunny" days
  - Clear-sky ramps: separate sunrise, midday, and sunset

Regulation Reserves for Western Interconn.

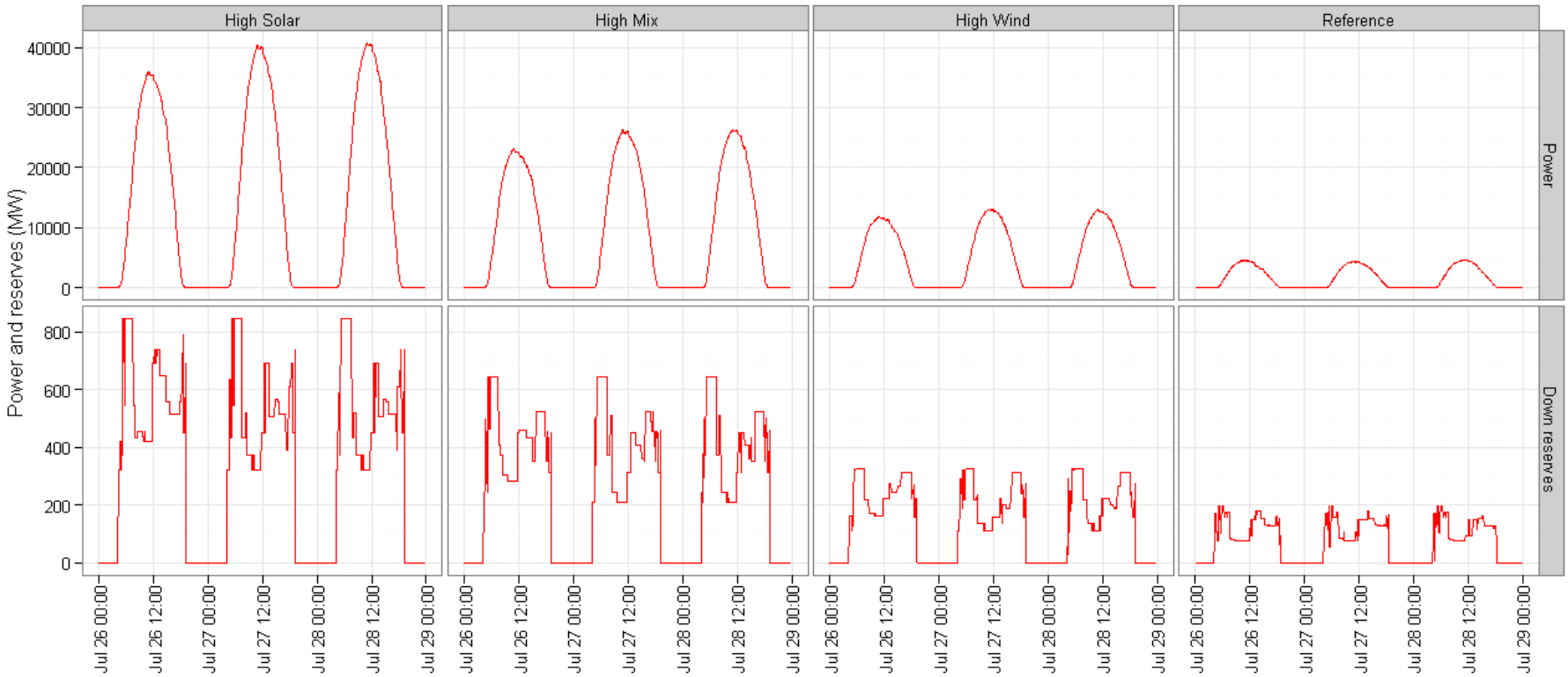


Flex Reserves for Southern California Edison



C) Application

- **Classify each step using the explanatory variables and using reserve requirement**



Flex Reserve Validation

Hypothesis

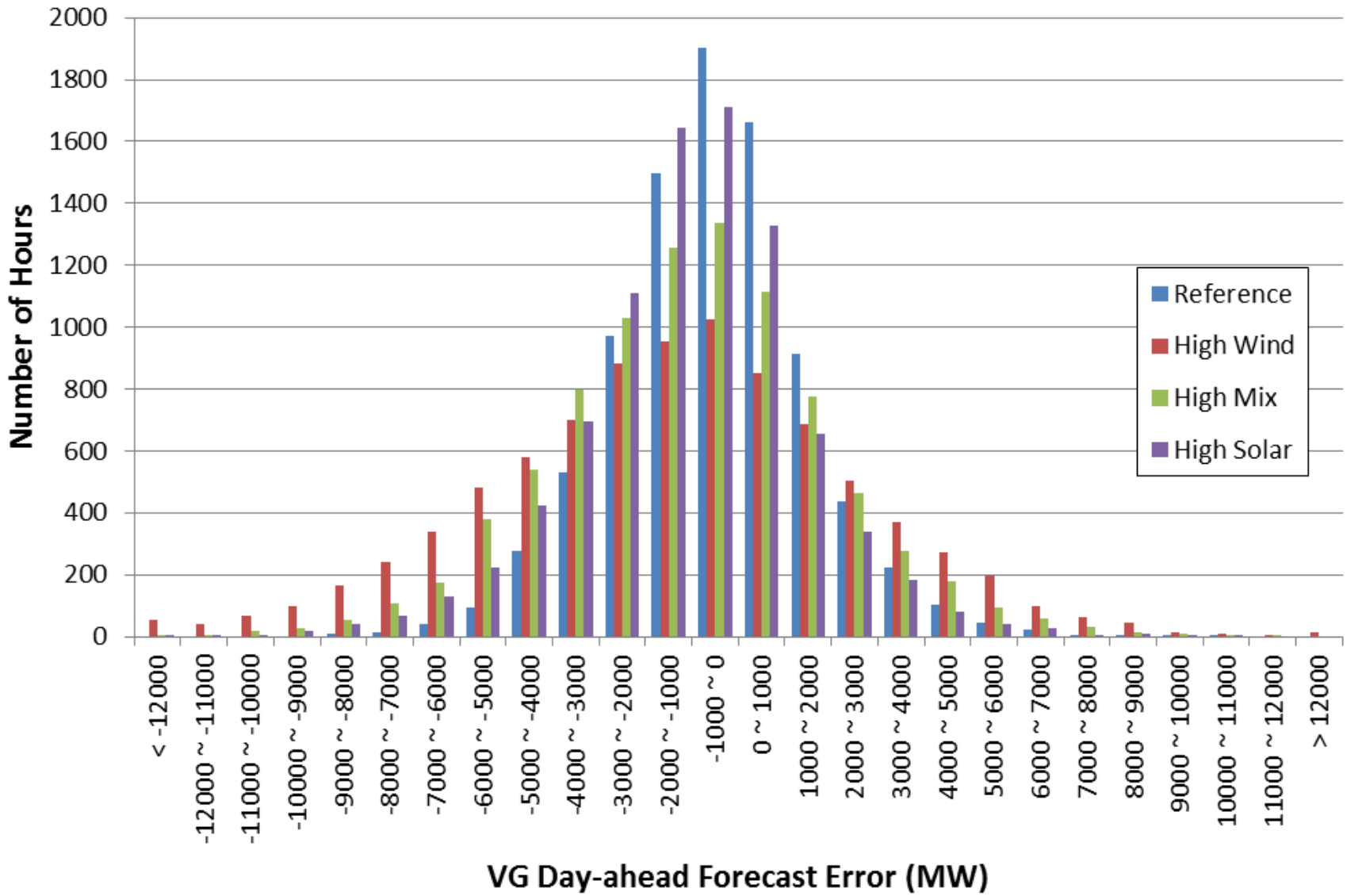
Flexibility reserves will improve power system reliability and/or lower cost

Cases

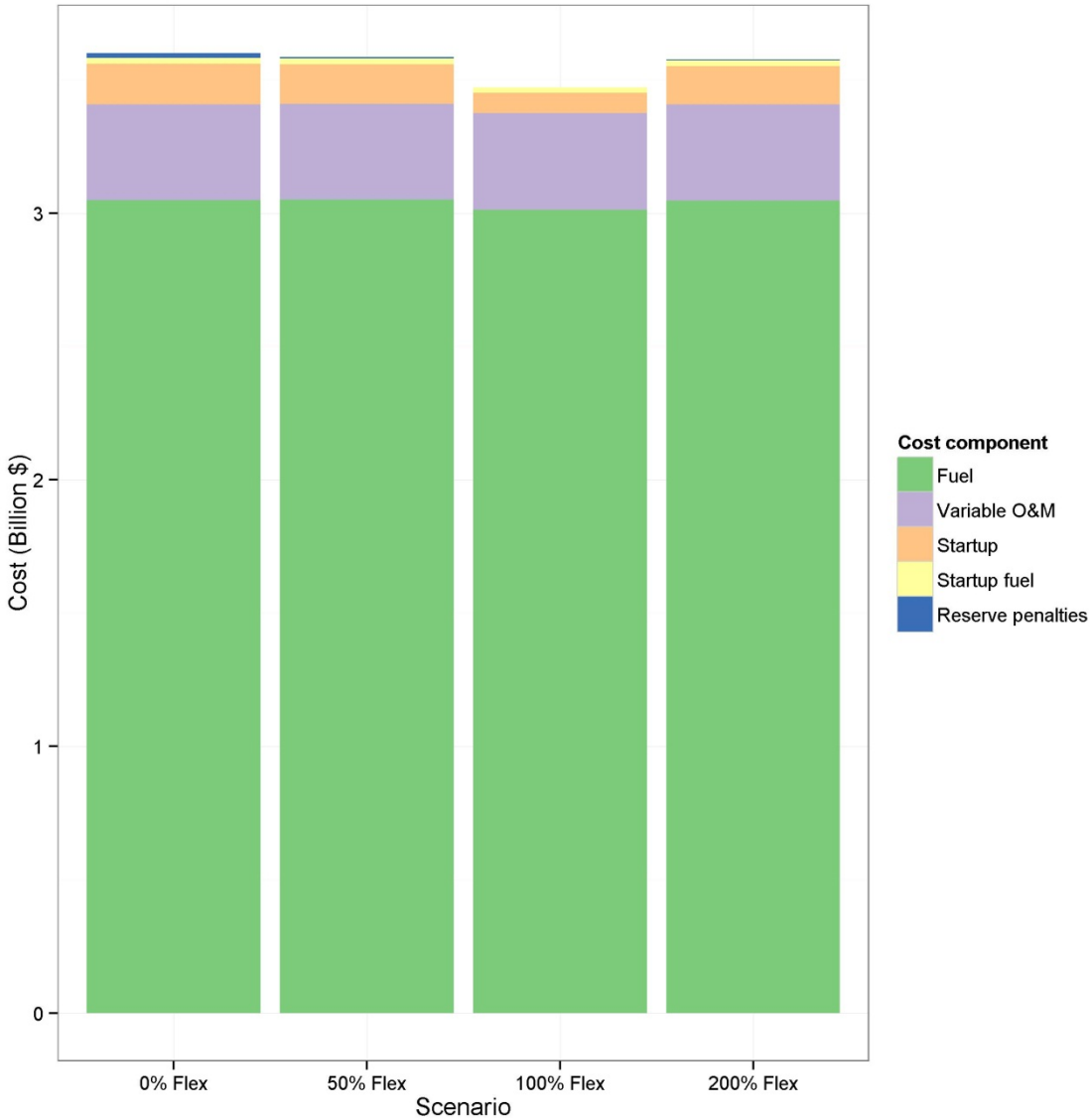
- **0% Flex**
- **50% Flex**
- **100% Flex**
  - Used in WWSIS-2
- **200% Flex**

- **All cases were run for April - July**
  - Full year takes ~6 days per case
  - Biggest differences occur in April

Day-ahead VG Forecast Error

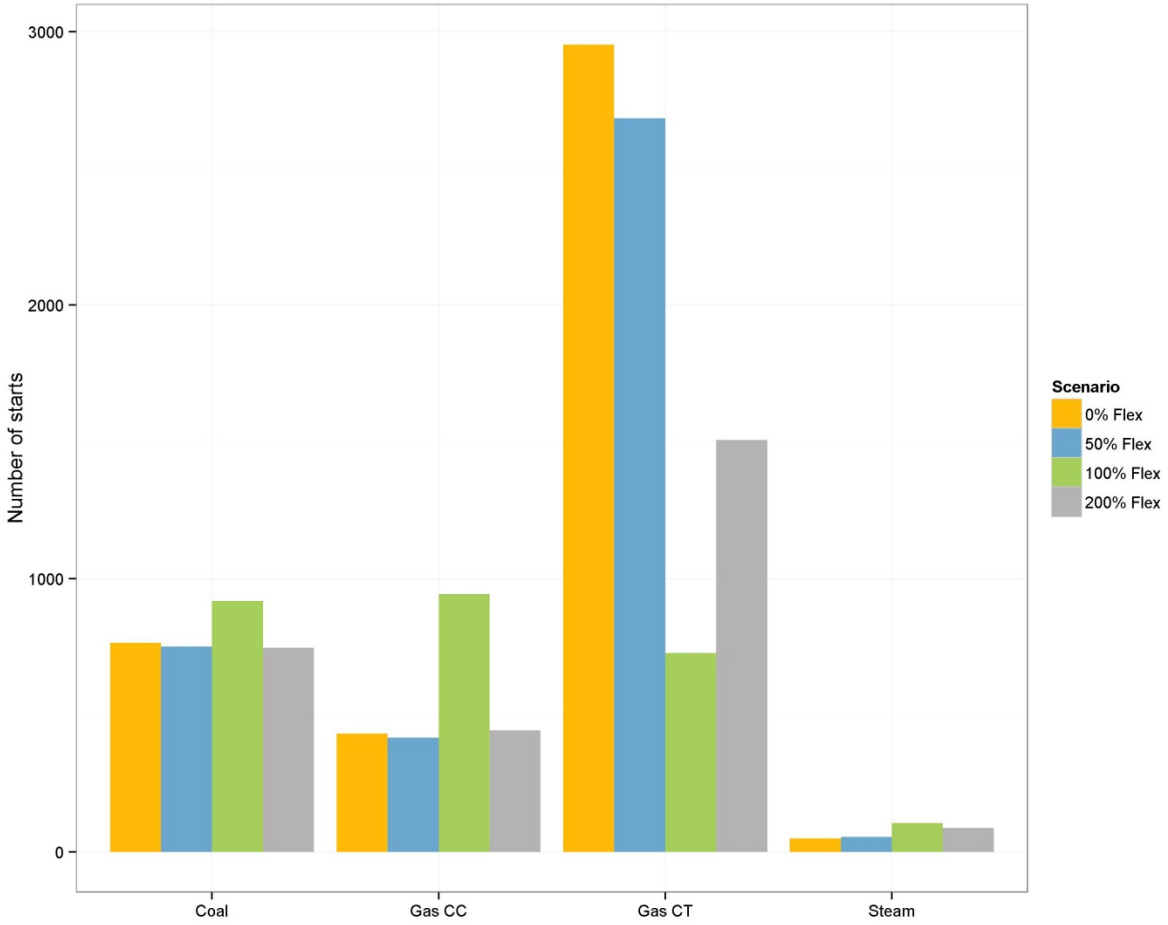


System production cost



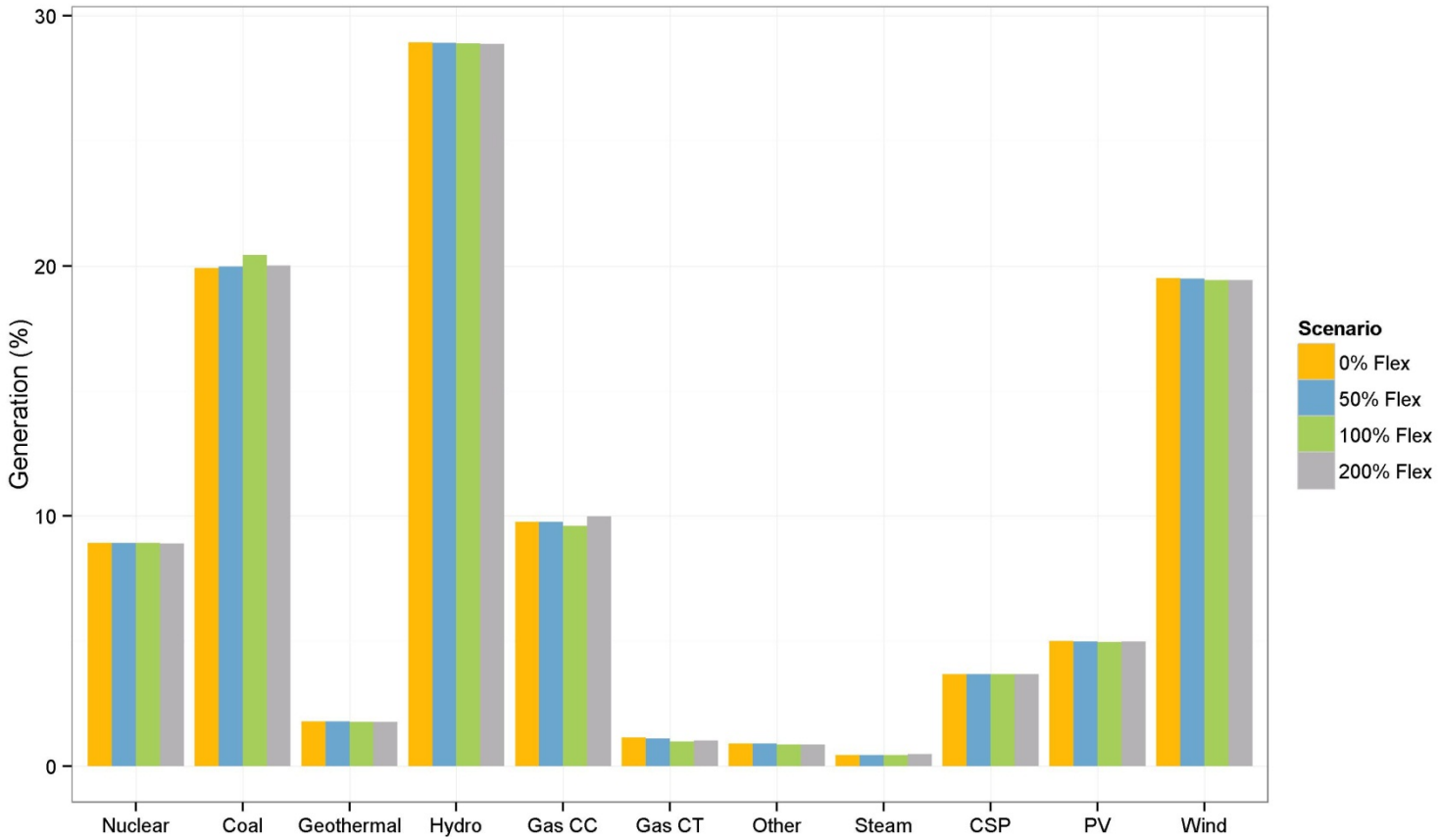
- 3.2% reduction in production cost (100% flex vs 0% flex)
- 3.7% reduction in objective function (production cost + penalties)

Startups by type



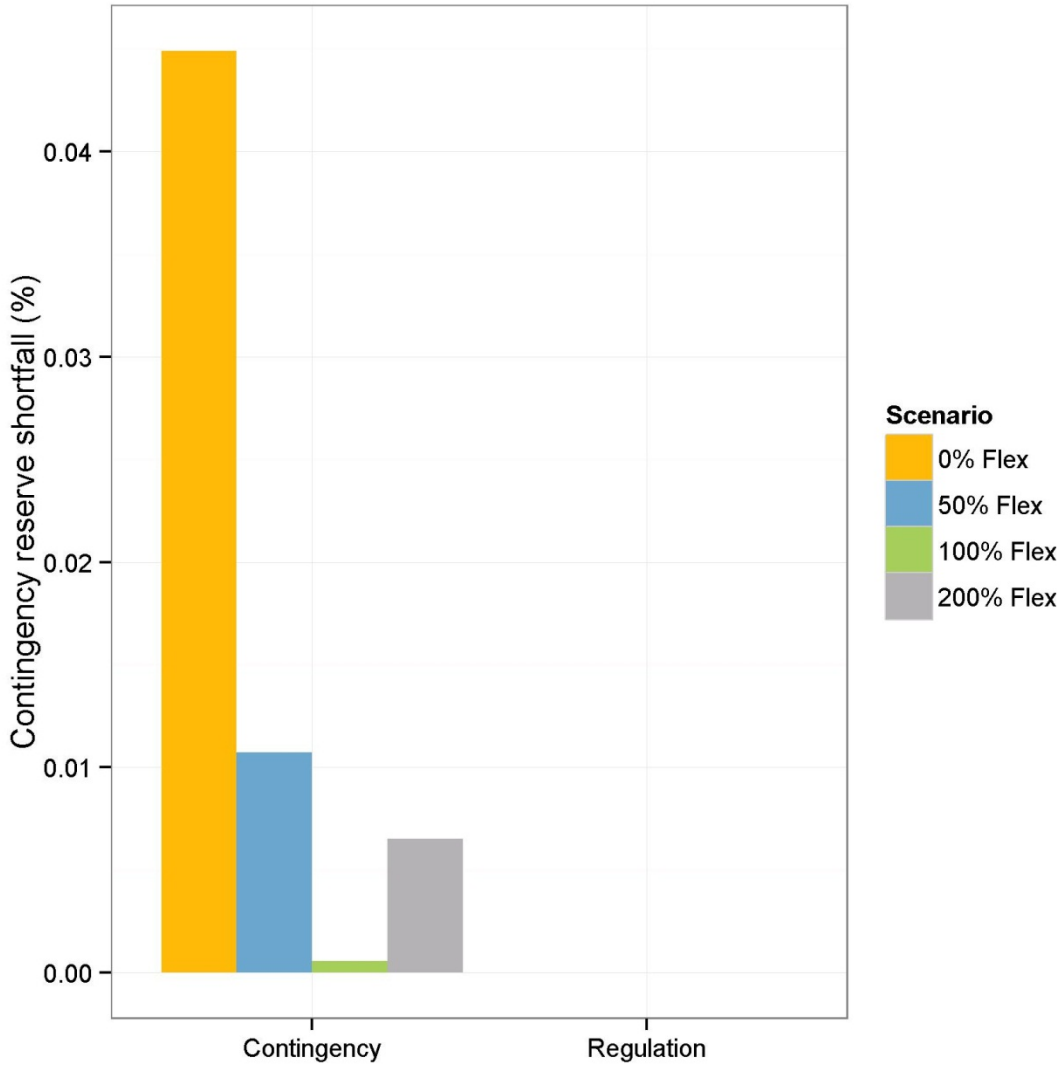
- **100% flex case has slightly more coal and gas CC, but much fewer CT starts**

Generation by type



- **100% flex case has slightly more coal, less gas CC and CT compared to other scenarios**

Reserve shortfalls



- **No unserved load in any case**
- **Minimum unserved reserves in 100% flex case**

Conclusions

- **A well-designed flexibility reserve product can reduce system cost**
  - For a system with significant uncertainties
- **A well-designed flexibility reserve product can reduce reserve shortages**
  - Improve reliability?
- **It is important to utilize a flexibility reserve product when modeling high-renewable scenarios**

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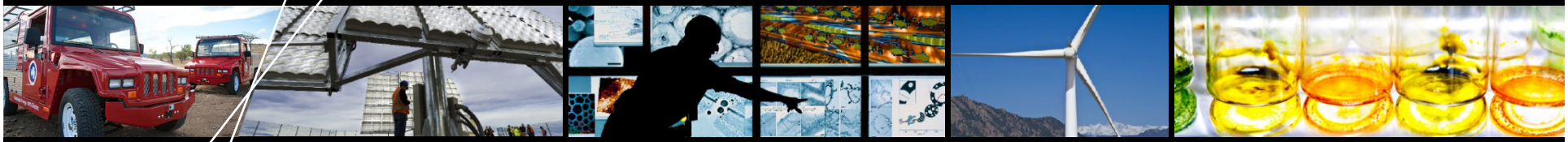

Additional slides