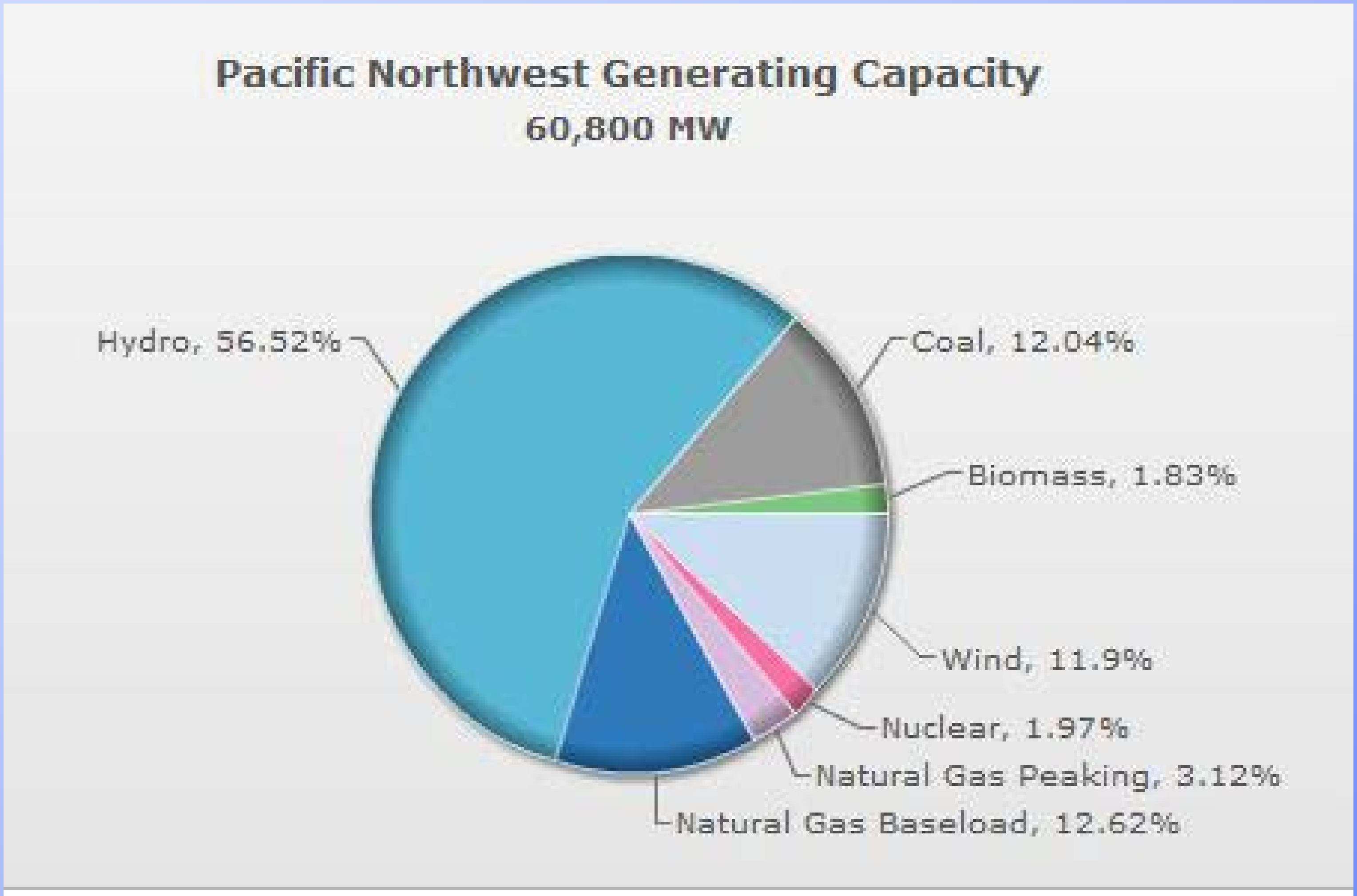
The Genesys Northwest Model
(Generation Evaluation System)

Bonneville Power Administration
Hydro Modeling Conference
February 21-22, 2012

Outline

1. The Pacific Northwest Power Supply
2. What is GENESYS?
3. Uses for GENESYS
4. Additional Slides

Pacific NW Power Supply



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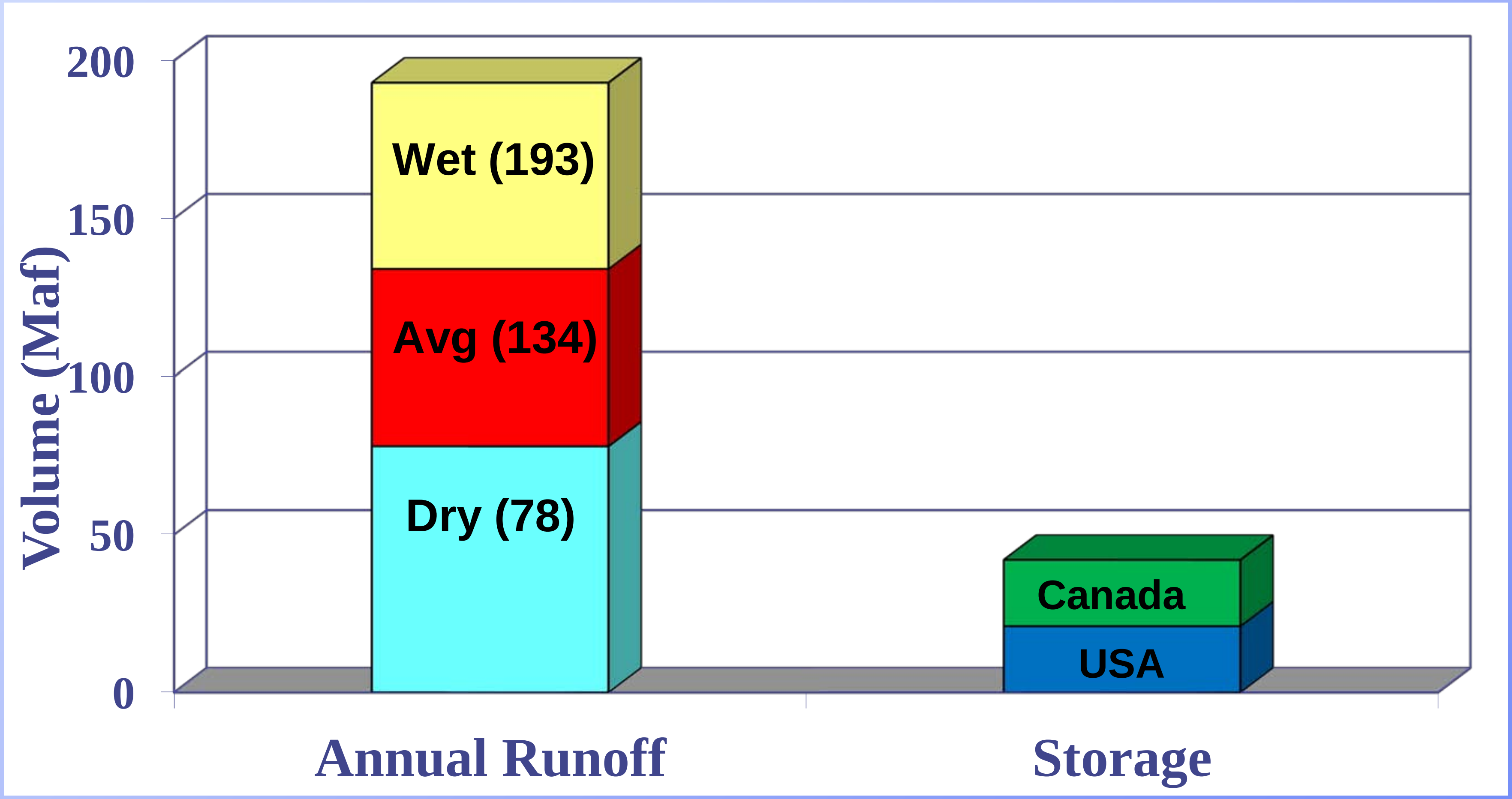
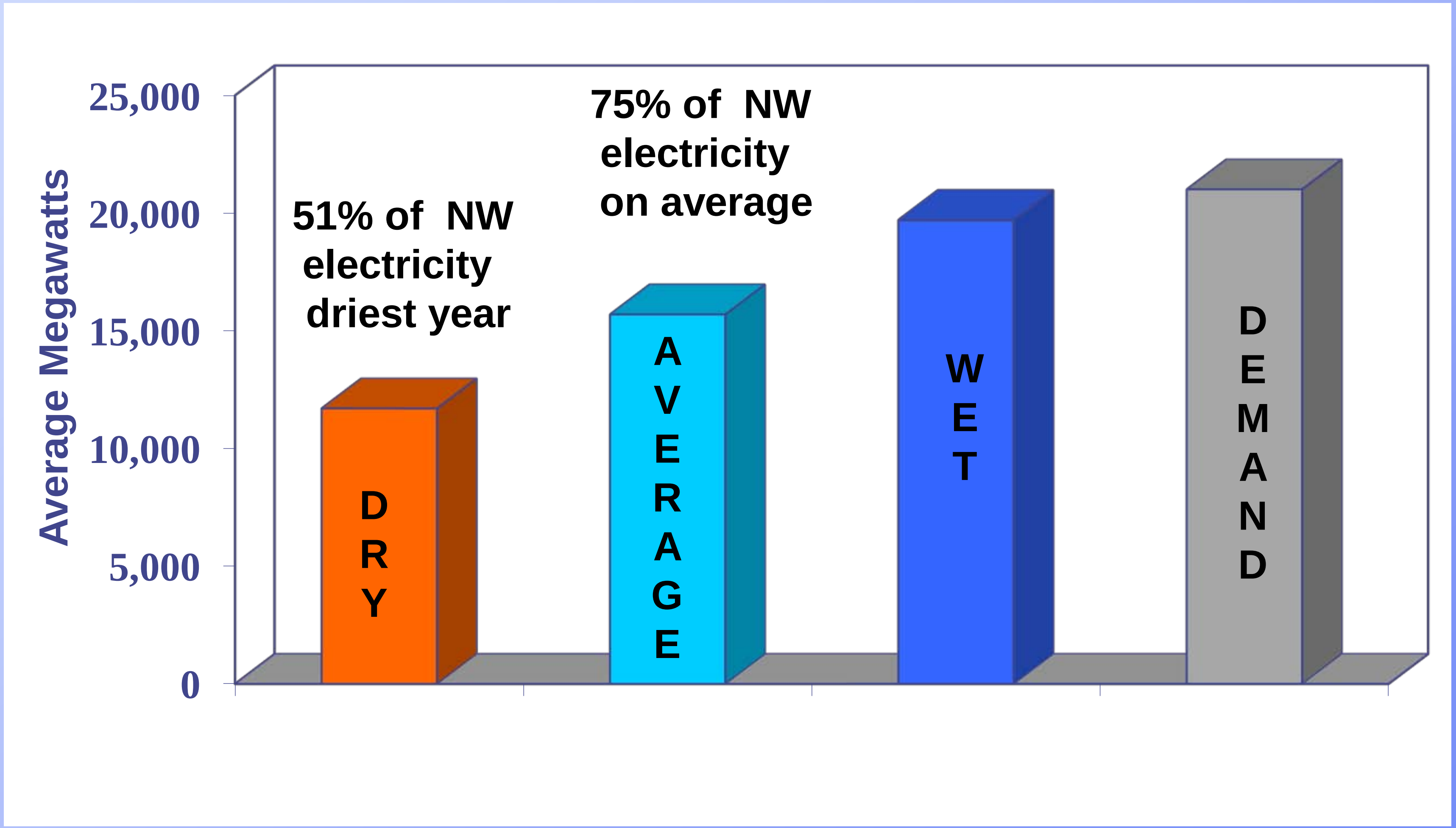
Reservoir Storage & Runoff Volumes



Variability in Hydroelectric Generation



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GENESYS Northwest

Monte Carlo Simulation of the NW Power Supply

Project-level Monthly Hydro Simulation

Hourly Economic Dispatch (including hydro)

Inter-regional Transmission Capacity (but not forced outages)

Random Variables:

- Water Conditions
- Temperature/Loads
- Thermal Resource Forced Outage
- Wind

Transmission Modeled in GENESYS

NW region includes:
East (E)
West (W)
Captain Jack (CJ)

Solid lines indicate transmission into and out of the region

Genesys Overview

- For each game
  - For each year
    - Select random variables
      - Water year
      - Temperature Year
      - Forced Outages
      - Wind Year
    - For each month
      - Build resource & load stack
        Do monthly dispatch
      - For each day
        - Get hydro peaking constraints
          Shape hydro generation
        - For each hour
          - Build resource & load stack
            Do hourly dispatch

Monthly Dispatch

- GENESYS builds a resource stack of available resources
- Cheapest resources on the bottom
- Hydro is broken into blocks with different prices
- GENESYS will dispatch enough resources, starting with the cheapest, until all load is met

Hydro Blocks – Based on Value of Water
(Not to Scale)

Daily/ Hourly Dispatch

- **Daily** – shape hydro energy to meet loads over 24 hours
  - Ensure no peaking violations occur
  - (see Trapezoidal model)
- **Hourly** – build load and resource stacks
  - Hourly hydro already assessed
  - Dispatch cheapest resources first

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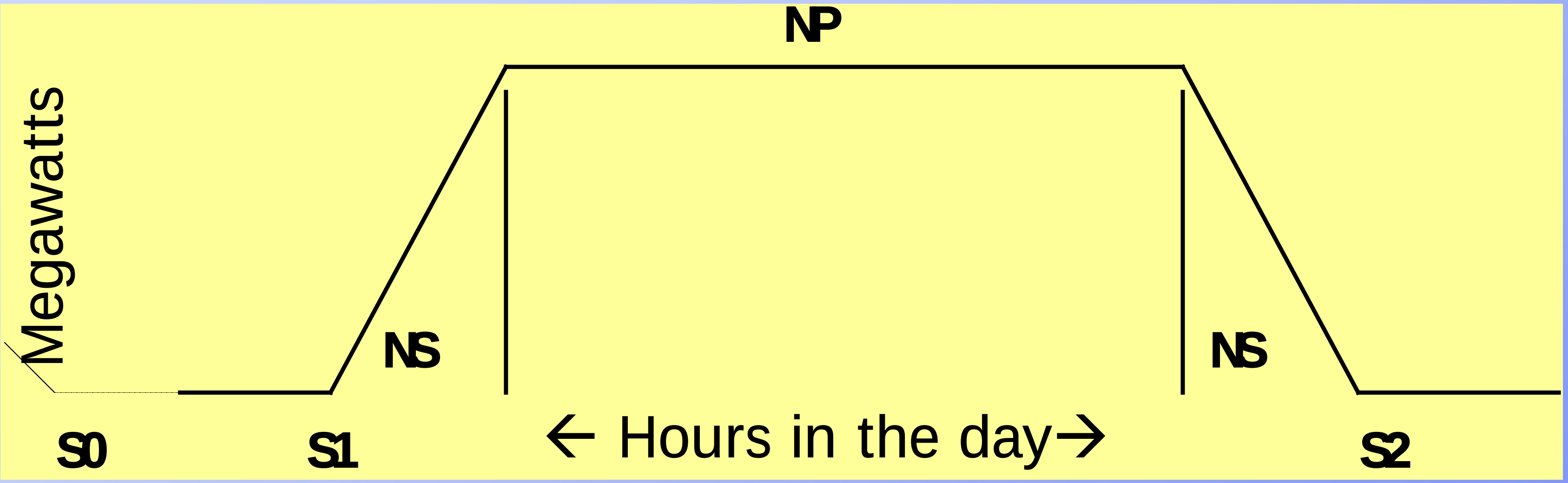
Trapezoidal Model



NP = Number of Peak Hours
NS = Number of Shoulder Hours
S0 = Storage at beginning of off-peak period
S1 = Storage at beginning of ramp up
S2 = Storage at end of ramp down

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Objective Function & Constraints

- Maximize on-peak generation
- Constraints
  - Min and max total flow limits
  - Max turbine flow limit
  - Min required spill level
  - End of week storage = beginning storage
  - Lag time between projects

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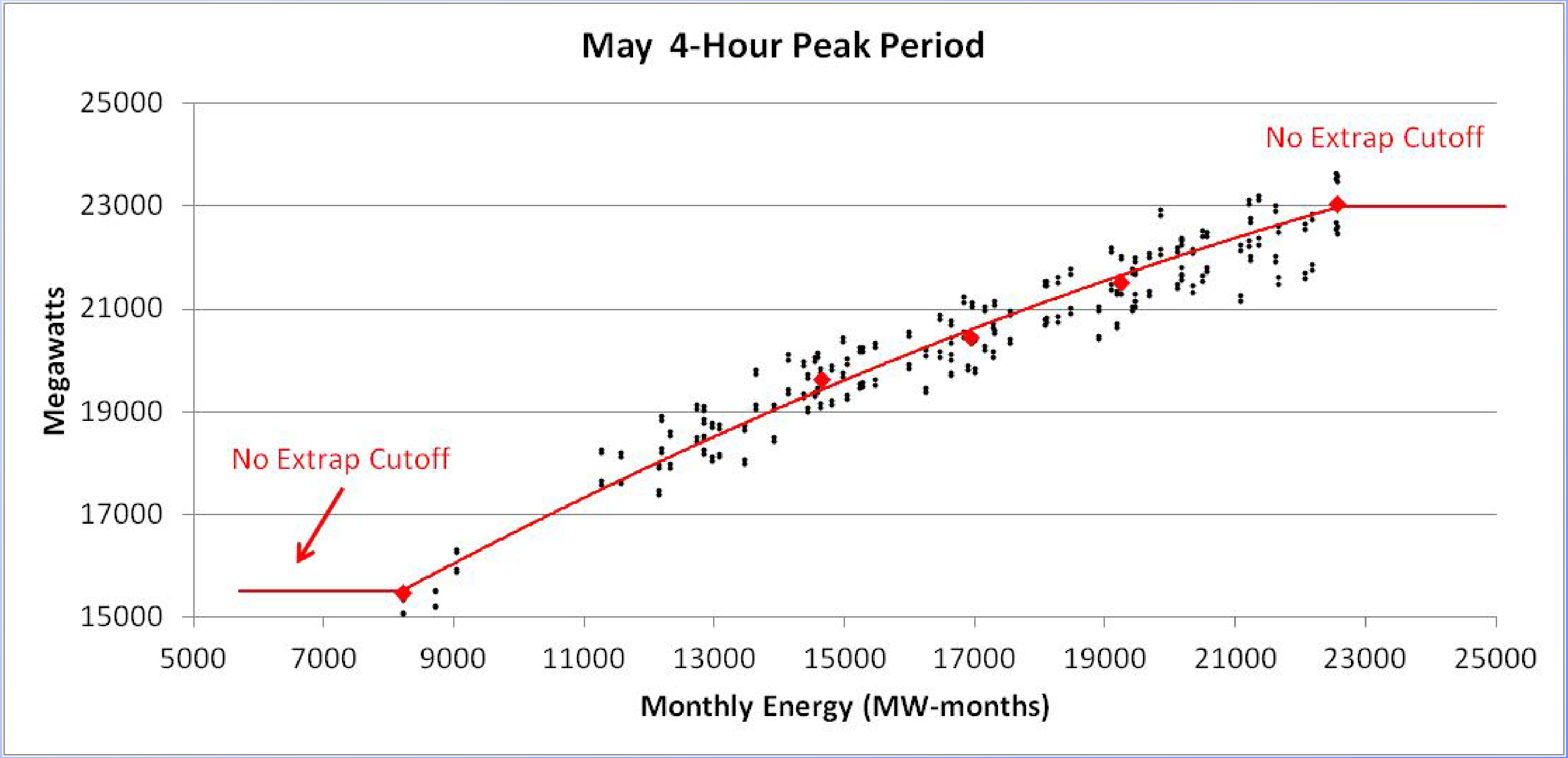
Peak vs. Energy Curve



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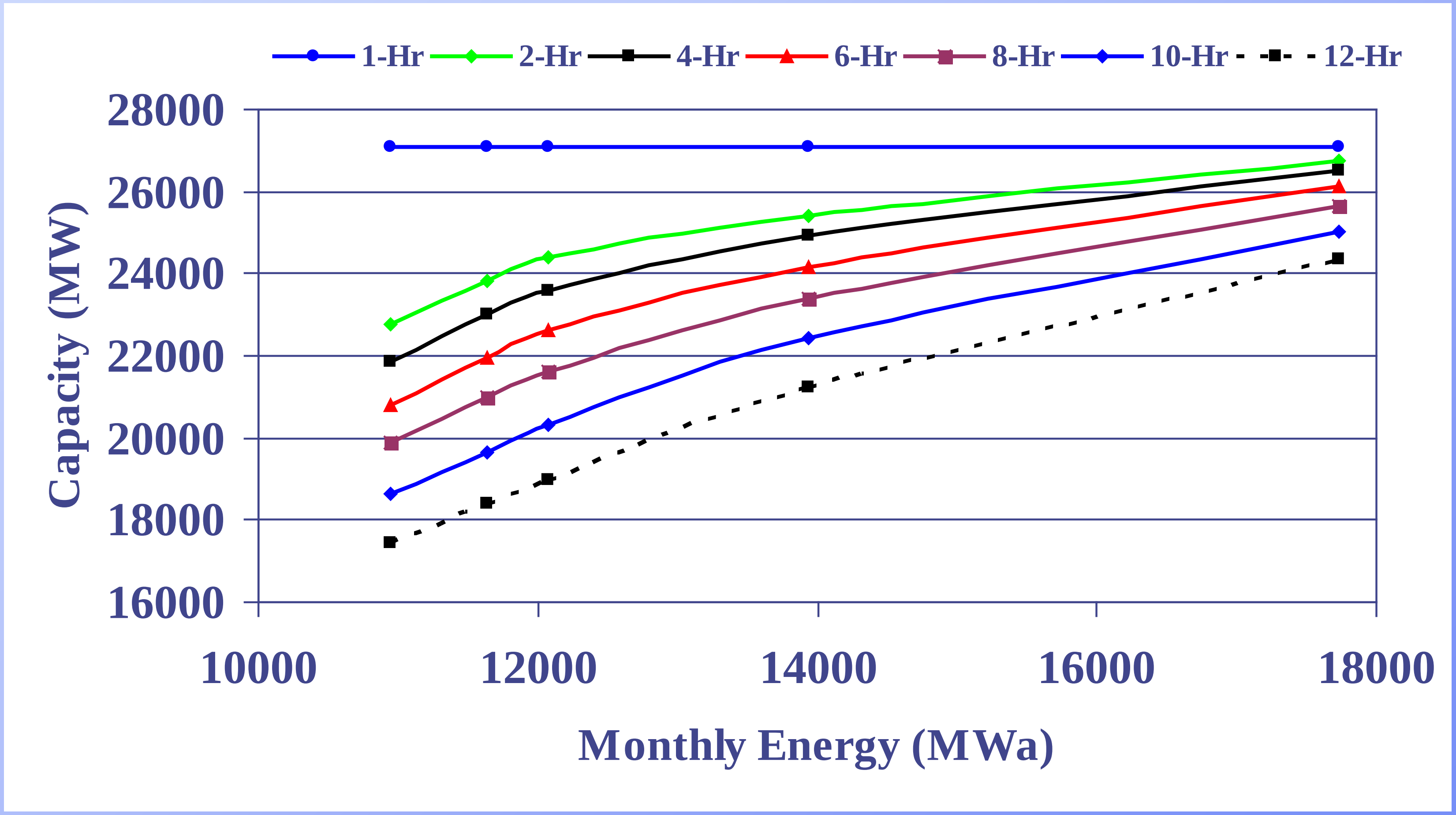
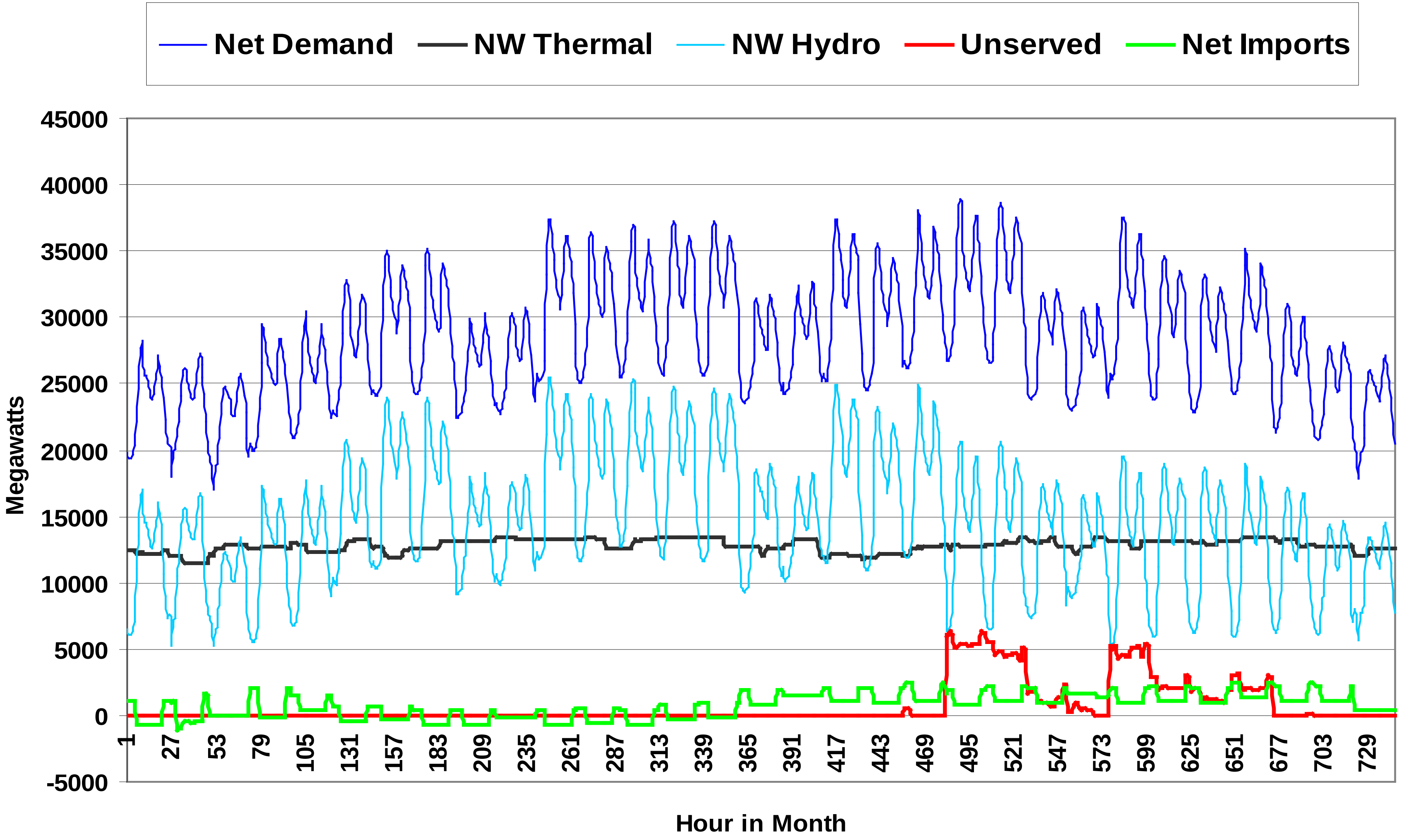
Peak vs. Energy Curves for 1, 2, 4, 6, 8, 10 and 12 Hours



Sample Simulated Dispatch



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Uses for GENESYS

1. Adequacy assessments
2. Impacts of increasing amounts of wind
3. Resource cost effectiveness
4. Impacts of alternative hydro operations
5. Sub-year hydro generation forecasts
6. Climate change studies

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Additional Slides

Effects of Wind on the Power Supply

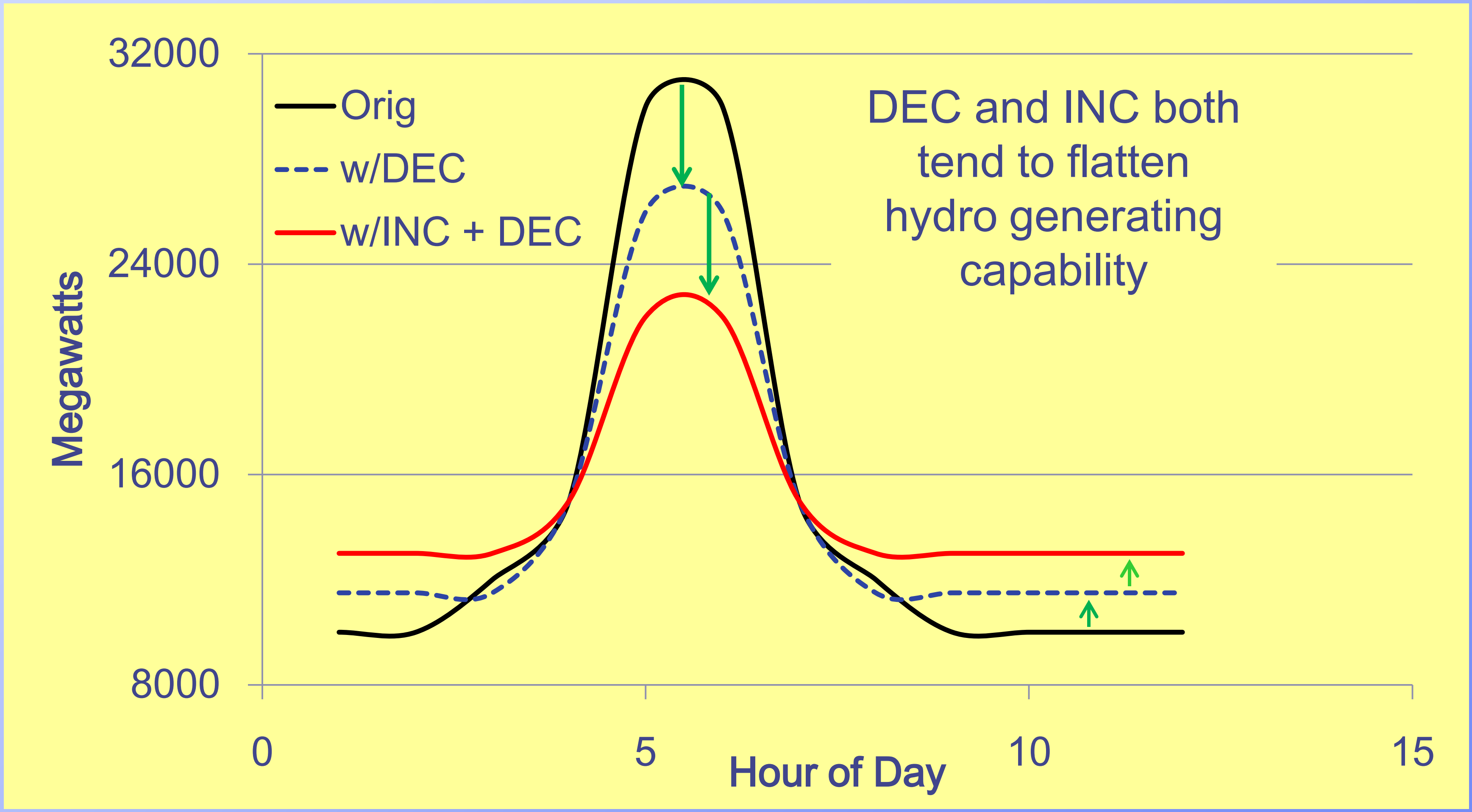
1. Hydro peaking capability reduction due to within-hour reserve requirements
2. Changes in thermal dispatch, more cycling and more small scale variation in hydro generation
3. Impacts to spring oversupply conditions
4. Calculate the effective load carrying capability of wind

Effects of Within-hour Wind Reserves on Hydro Capability

INC Reserve – Generation dispatched during peak load when wind doesn't blow

DEC Reserve – Generation turned off during light load when wind does blow

Effects of INC and DEC Reserves on Hydroelectric Capability



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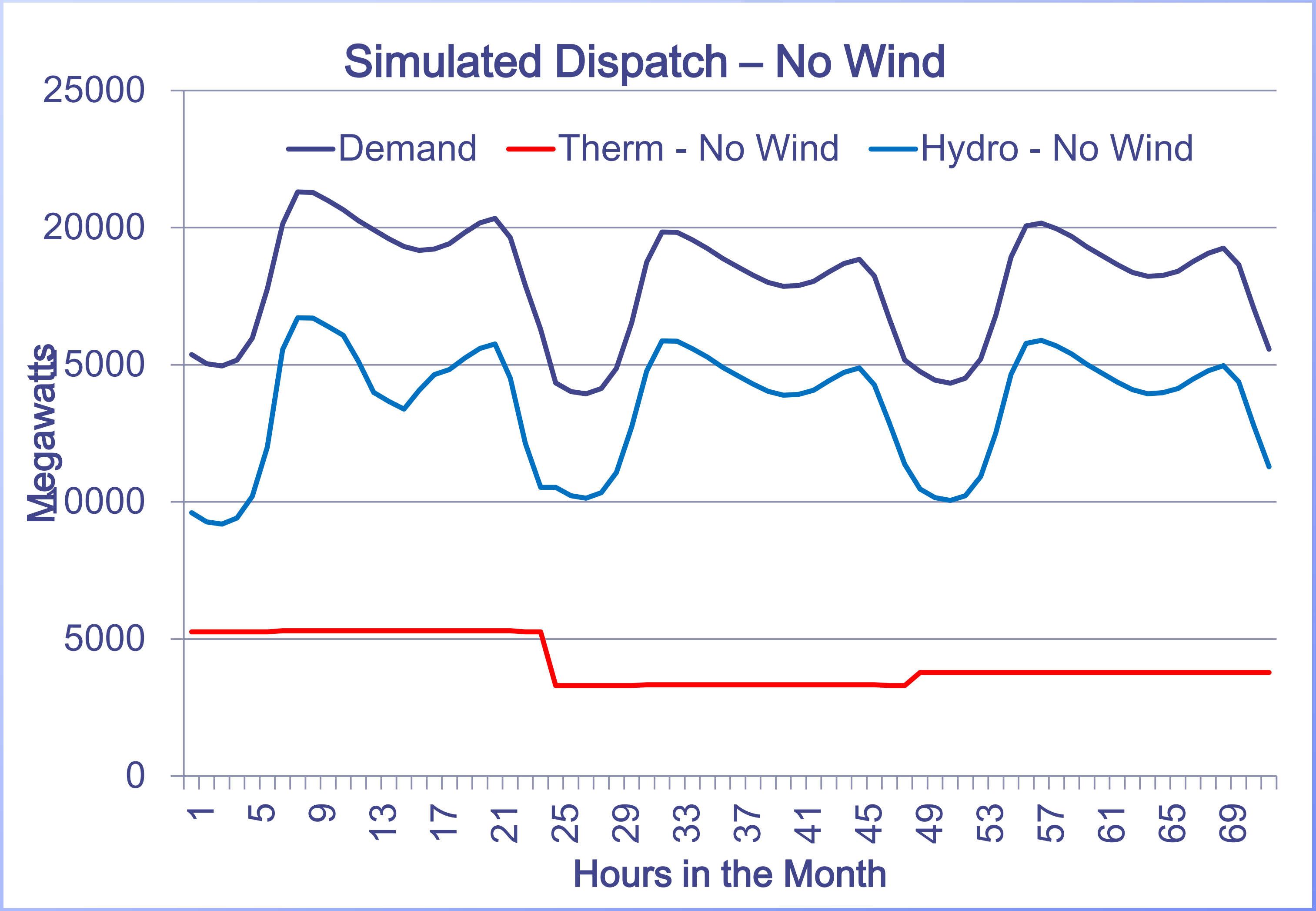
Impacts to Resource Dispatch



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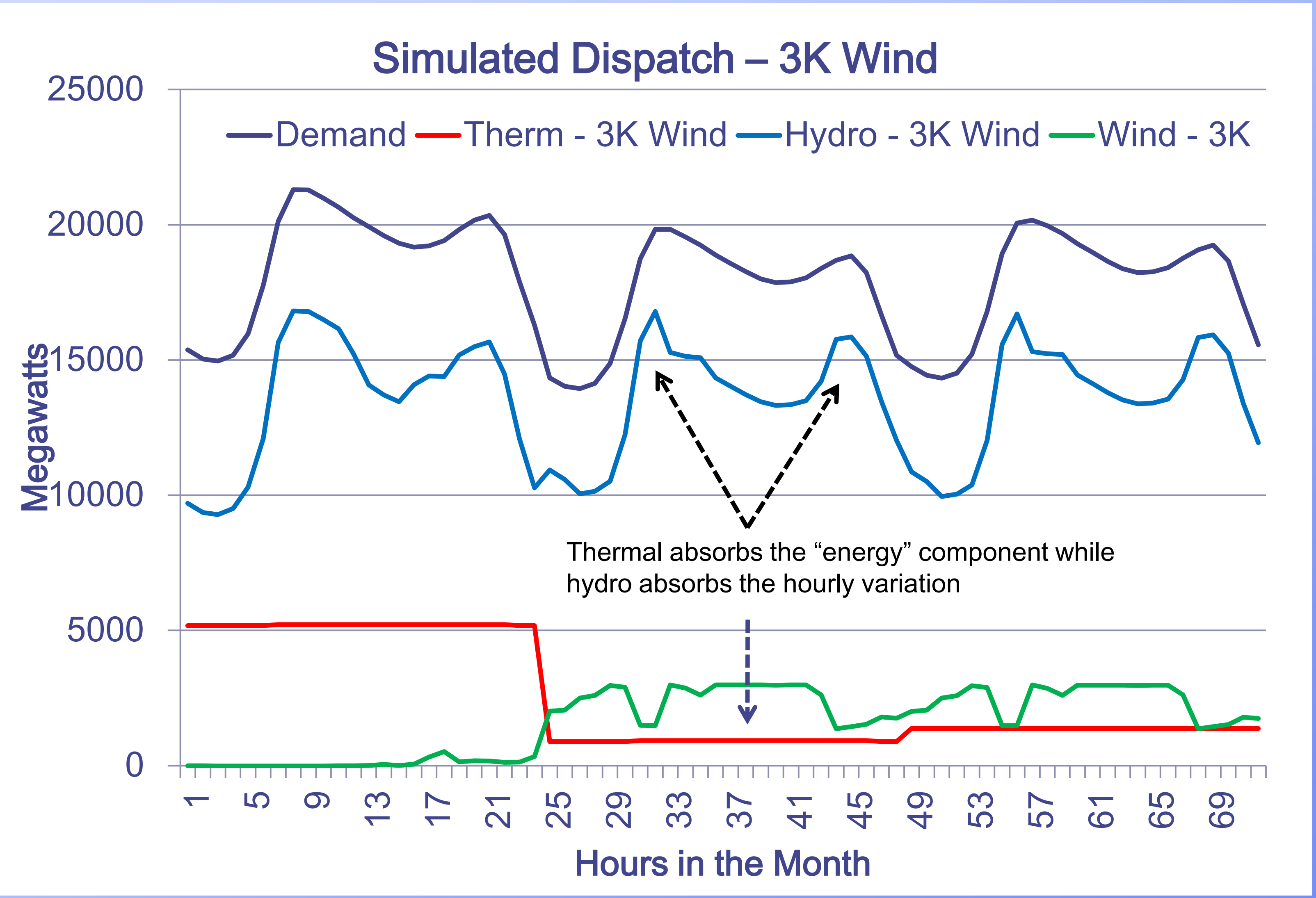

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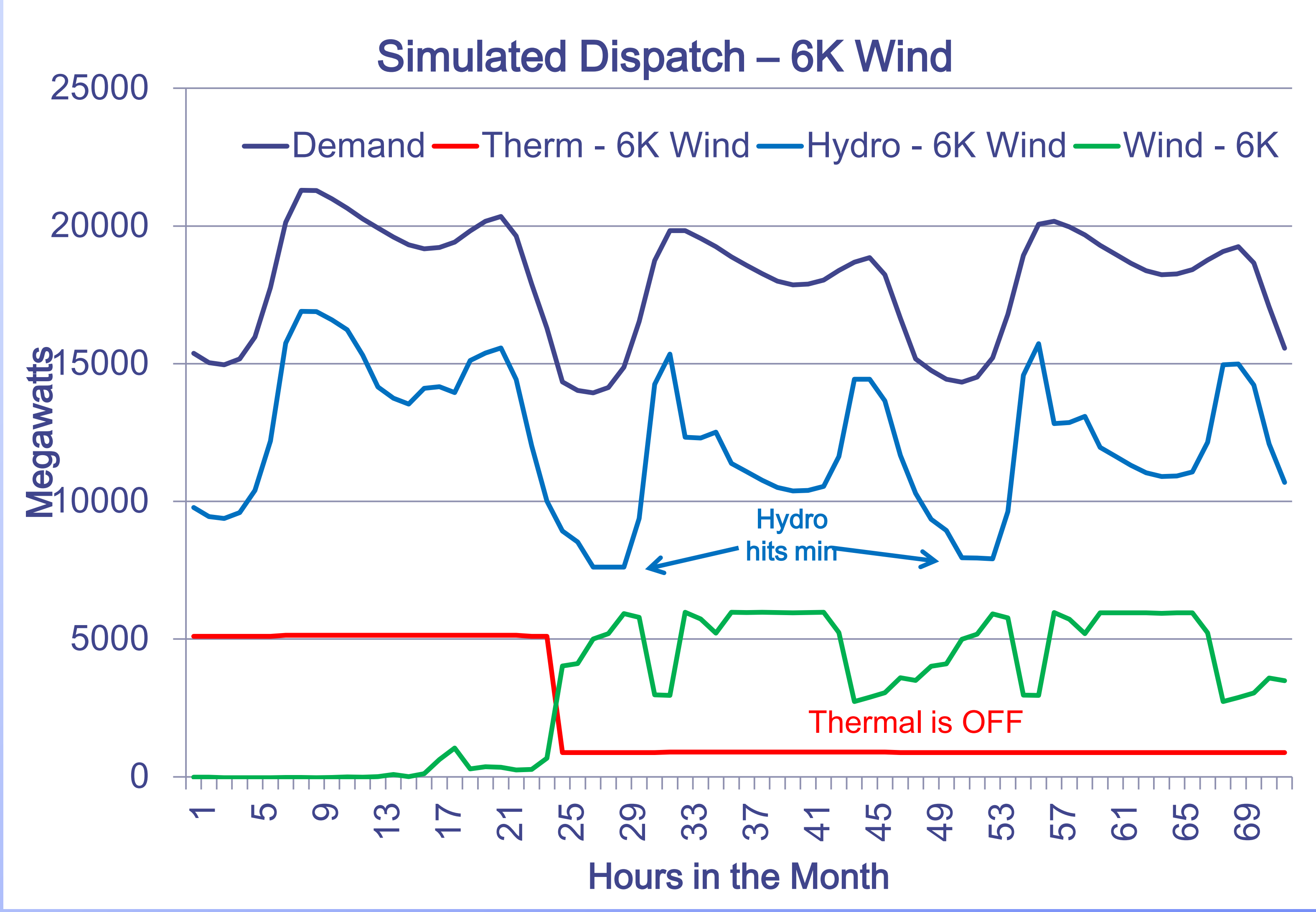

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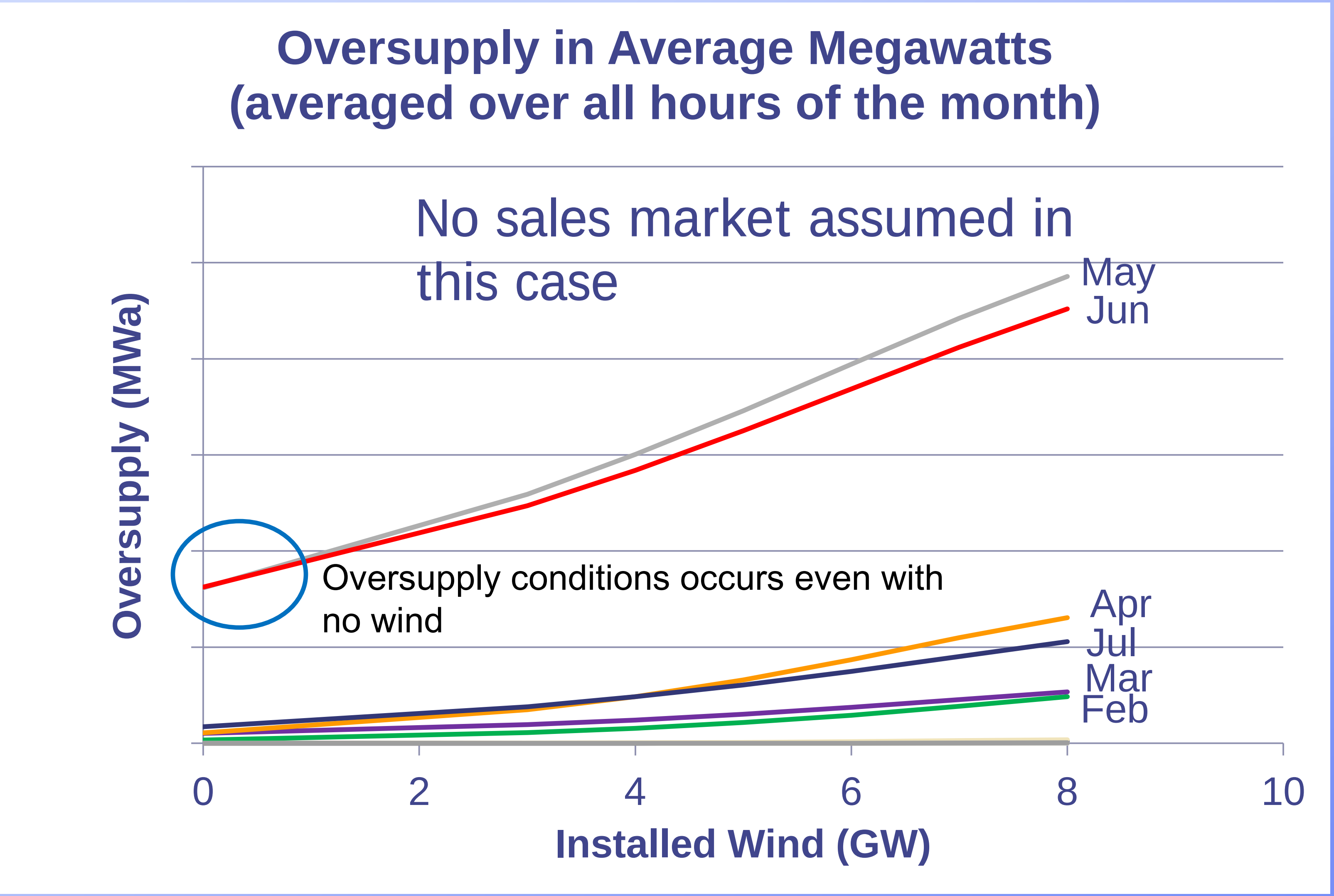
Oversupply Conditions

Oversupply conditions occur when the minimum system generation exceeds firm load and secondary sales markets.



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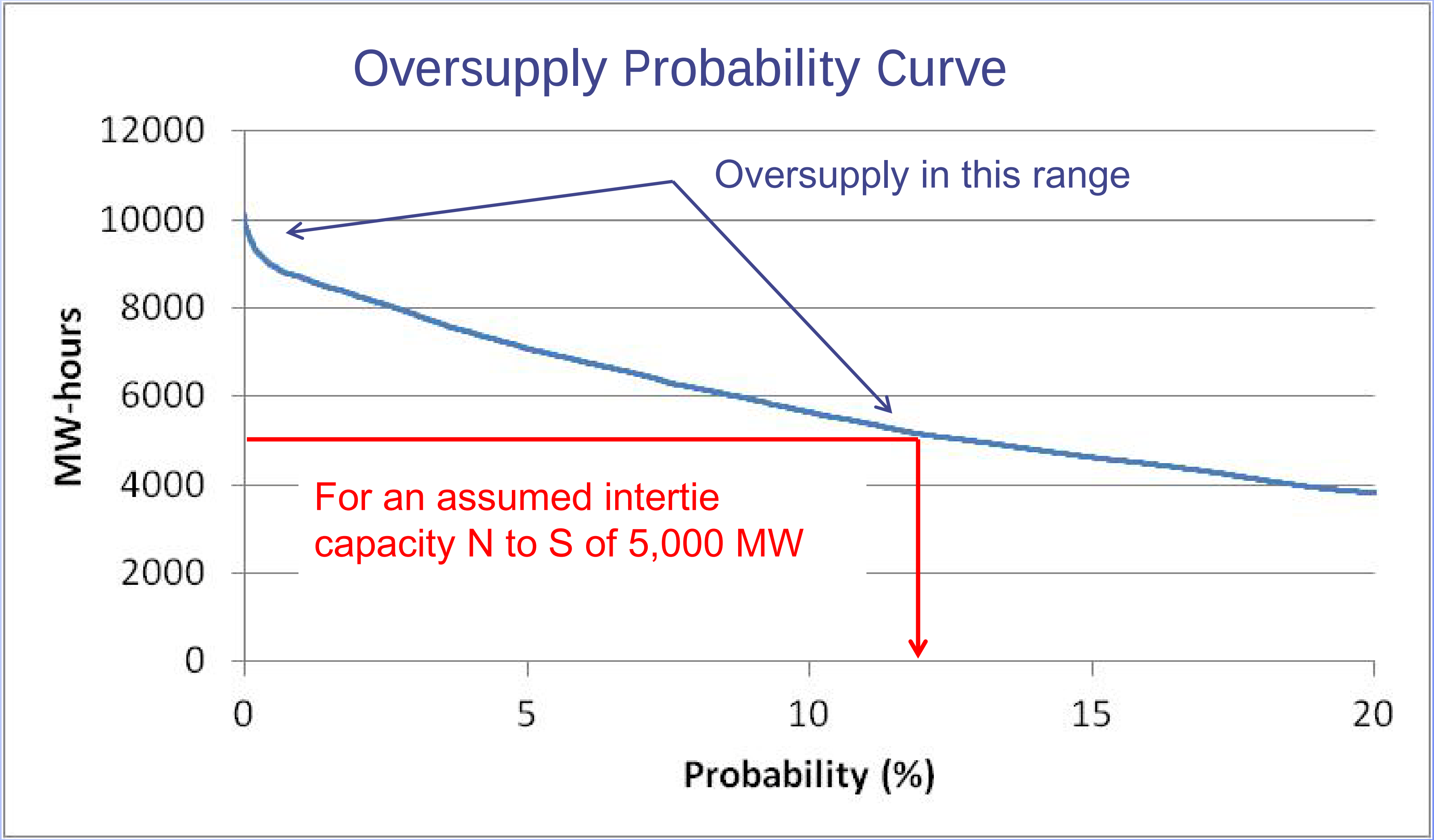

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Effective Load Carrying Capability of Wind

What is ELCC?

- "Effective load carrying capability" is defined as the amount of incremental load a resource can serve without degrading adequacy.
- It is usually expressed as a percentage of a resource's nameplate capacity.
- ELCC is a function of the system the resource is added to – this is particularly important for wind.

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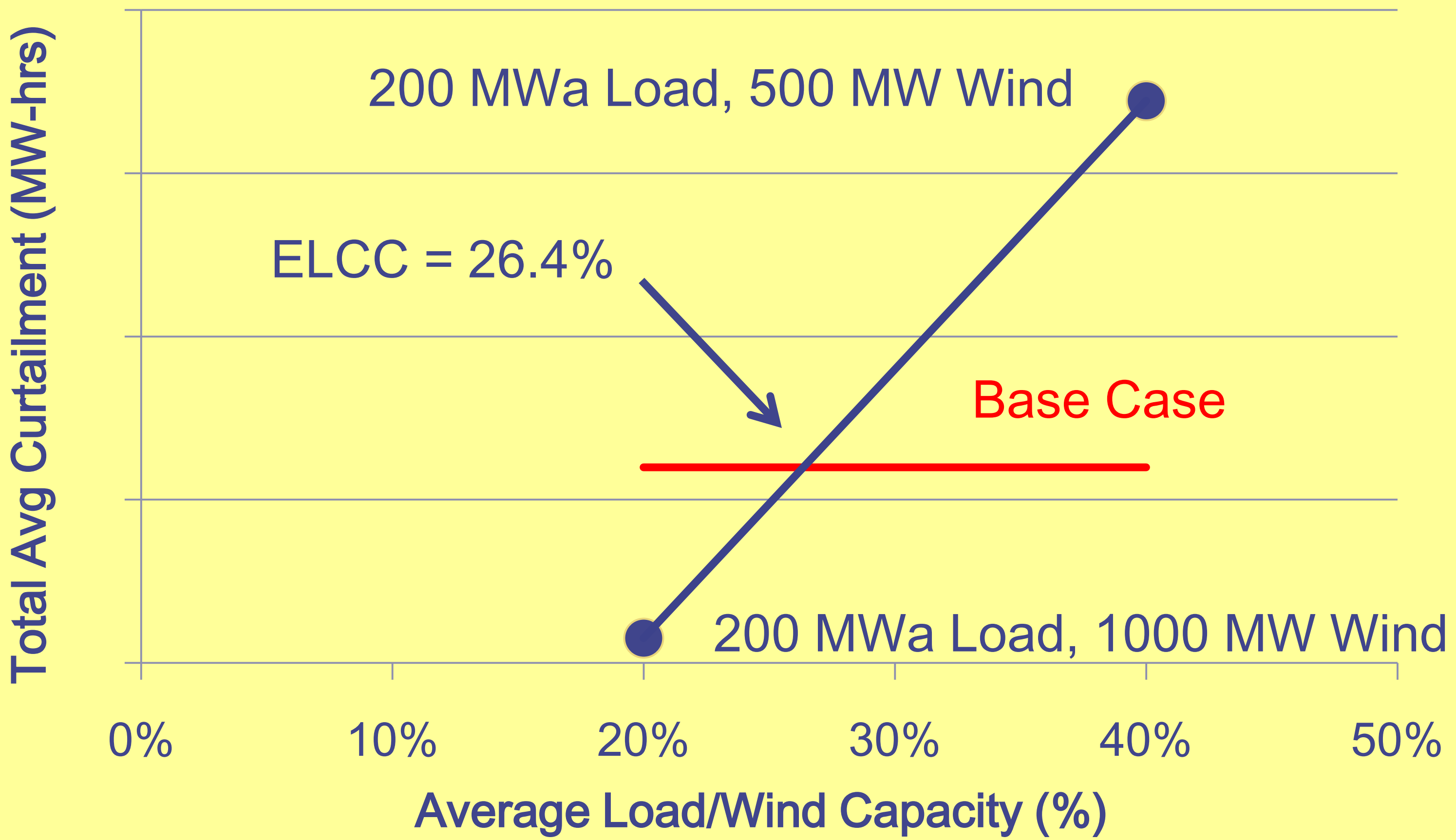
Study Methodology

- Base case
  - Remove all wind
  - Calculate total annual average curtailment
- Study cases
  - Add 200 MWa of annual shaped load
  - Add increments of wind capacity until the total annual average curtailment equals that in the base
  - Wind data based on historic 2008-10 BPA wind fleet production
  - Repeat above with greater amounts of load

ELCC Results (+200 MWa load)



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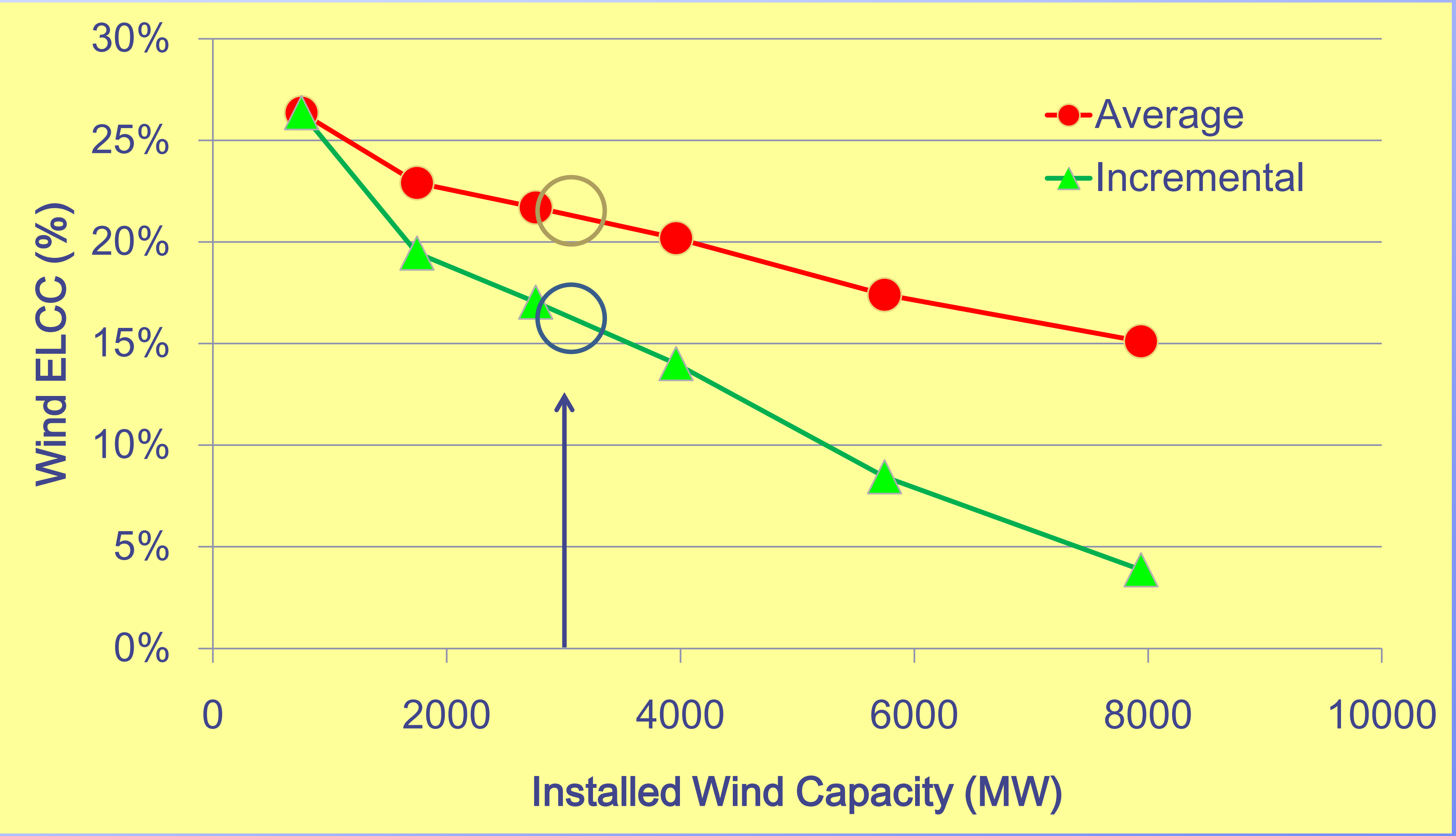
Annual Wind ELCC Results



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Observations

- ELCC declines with increasing amounts of wind because system flexibility is used up
- Eventually wind ELCC will flatten out
- Average annual wind generation is ~ 30%, yet currently aggregate ELCC is ~ 18% Thus, can't plan on average wind generation
- Adding storage will increase ELCC
- Adding more diverse wind generation will also increase aggregate ELCC

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