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How Important is Sub-Hourly Modeling in Renewable Integration Studies

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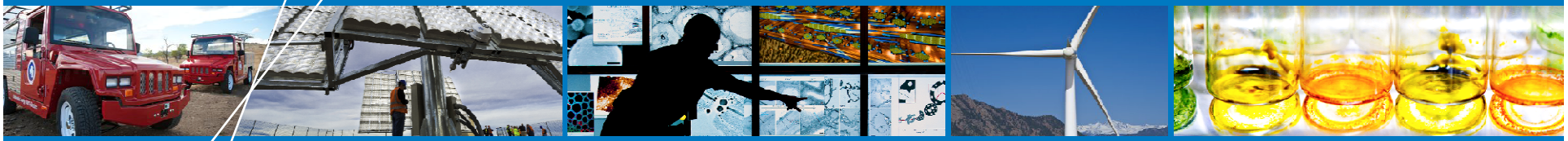


Modeling, Simulation and Optimization for the 21st Century Electric Power Grid

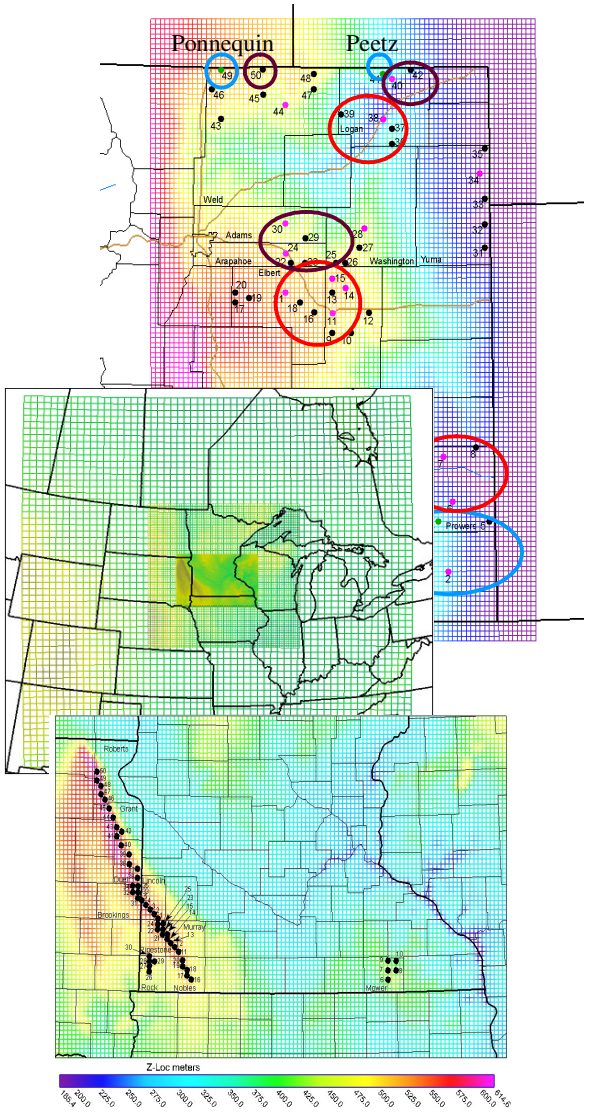
Greg Brinkman

(presentation by Paul Denholm)

October 23, 2012

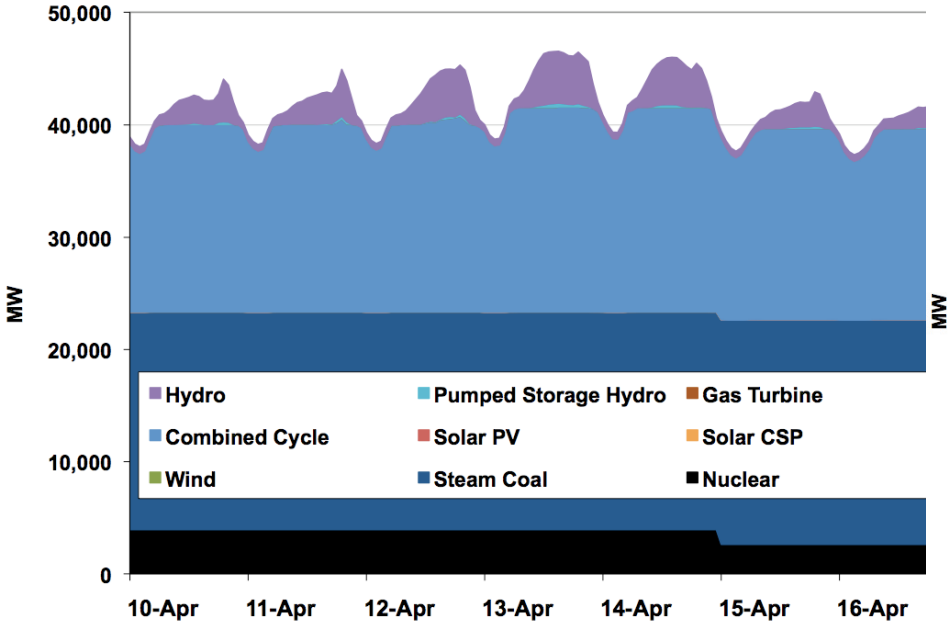
Renewable Integration Studies

- Evaluate the cost, reliability impacts of solar and wind
- Identify new operational practices needed

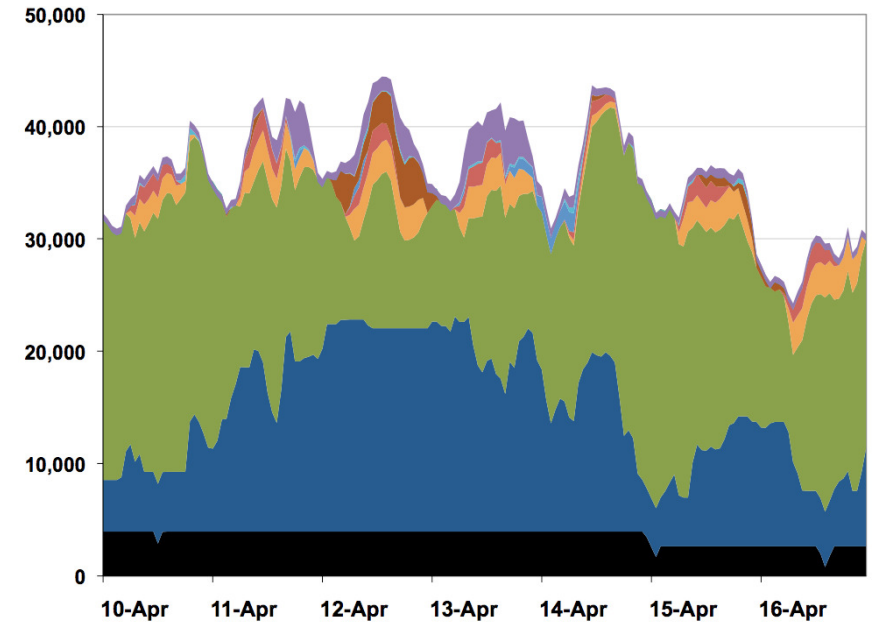


Example – WWSIS

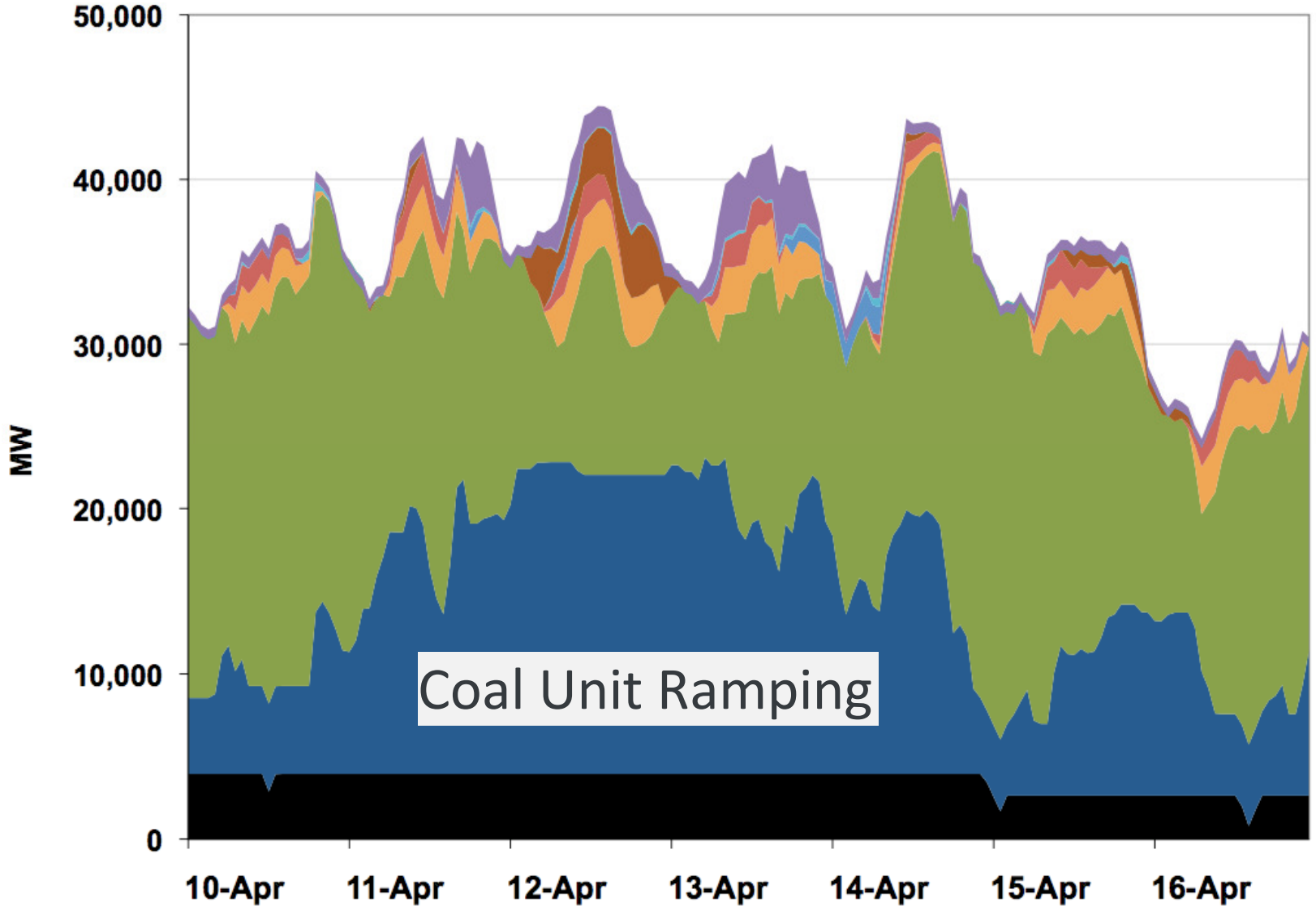
No Wind/Solar



High renewables case



Example – WWSIS



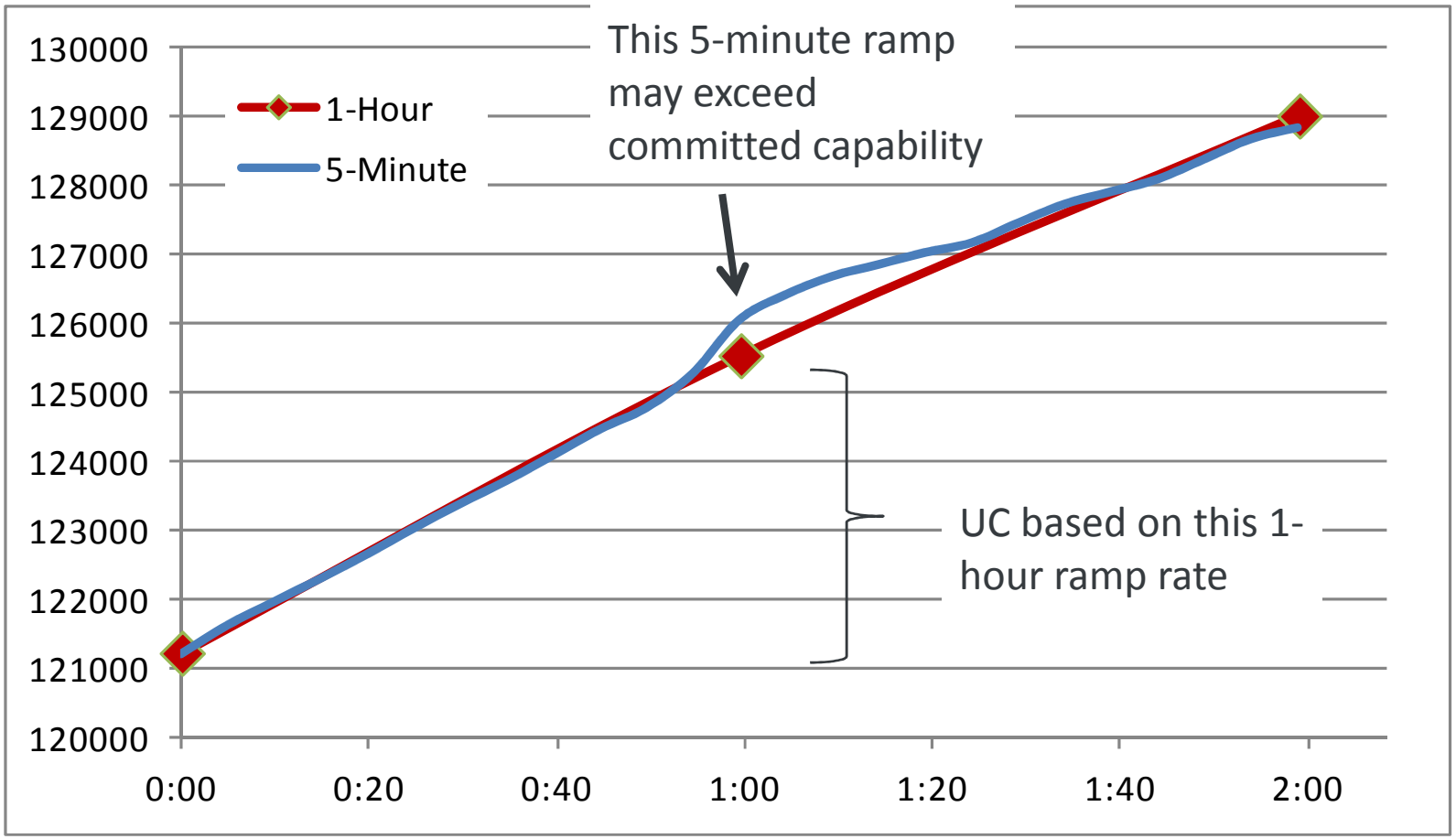
Evolution

- **Need to acknowledge and address limitations of previous analysis**
  - Ramp rates
  - Cost of cycling
  - Change in reserve requirements
  - Forecast error and uncertainty
  - Other “more technical” stuff (inertia, increase in actual regulation response, transient stability)
- **BUT -given an infinite number of sensitivities and finite number of computers, need to identify the key drivers behind integration challenges**

This analysis

- Begin to move integration studies from 1-hour dispatch to 5-minute dispatch intervals
- Understand basic importance of subhourly modeling – how sensitive are results?
- Not a comparison of subhourly scheduling practices!

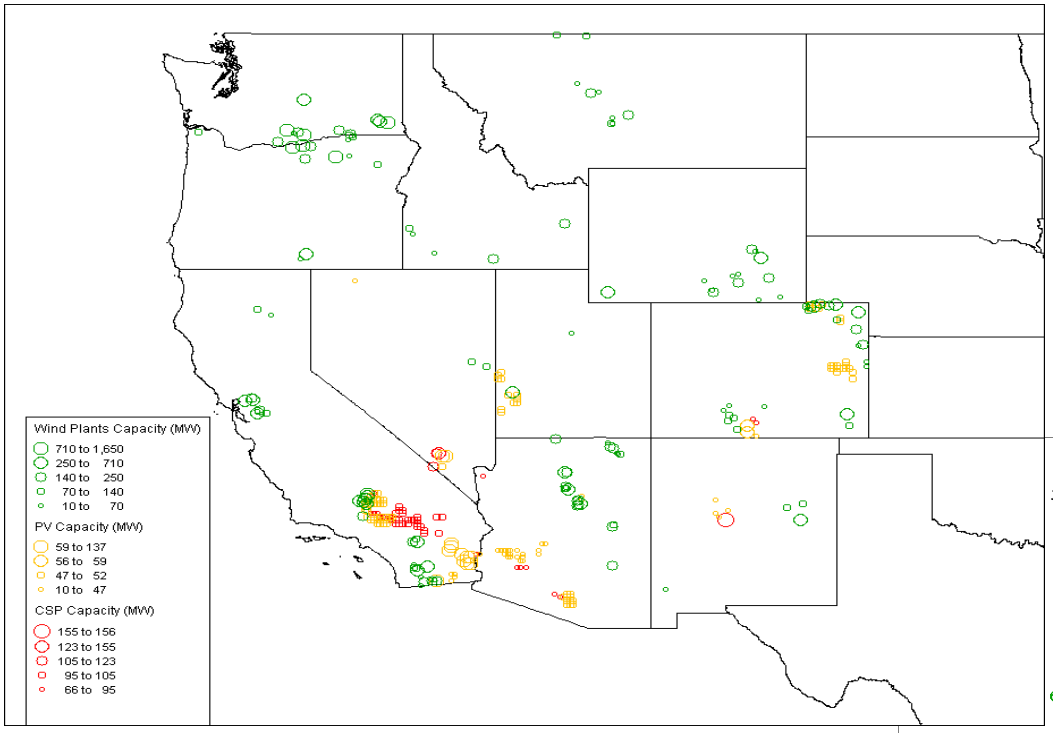
Framework


130000
129000
128000
127000
126000
125000
124000
123000
122000
121000
120000
0:00
0:20
0:40
1:00
1:20
1:40
2:00
1-Hour
5-Minute
This 5-minute ramp may exceed committed capability
UC based on this 1-hour ramp rate

Methodology

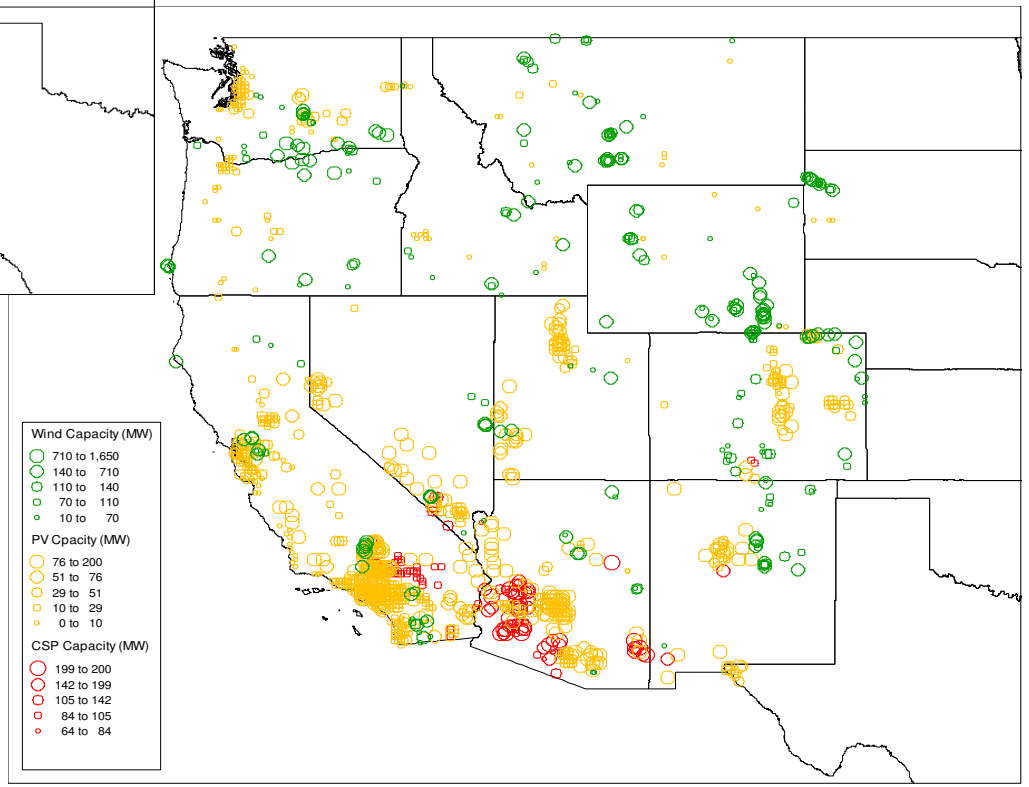
- **PLEXOS unit commitment and dispatch modeling**
  - Day ahead market (hourly)
    - Coal and nuclear units committed
  - 4 hour ahead market (hourly)
    - Better forecasts
    - Gas CC and steam units committed
  - Real time market (tested hourly vs subhourly)
    - Gas CT committed and dispatched

WWSIS Core Scenarios



Reference
8% wind
3% solar

High Mix
16.5% wind
16.5% solar

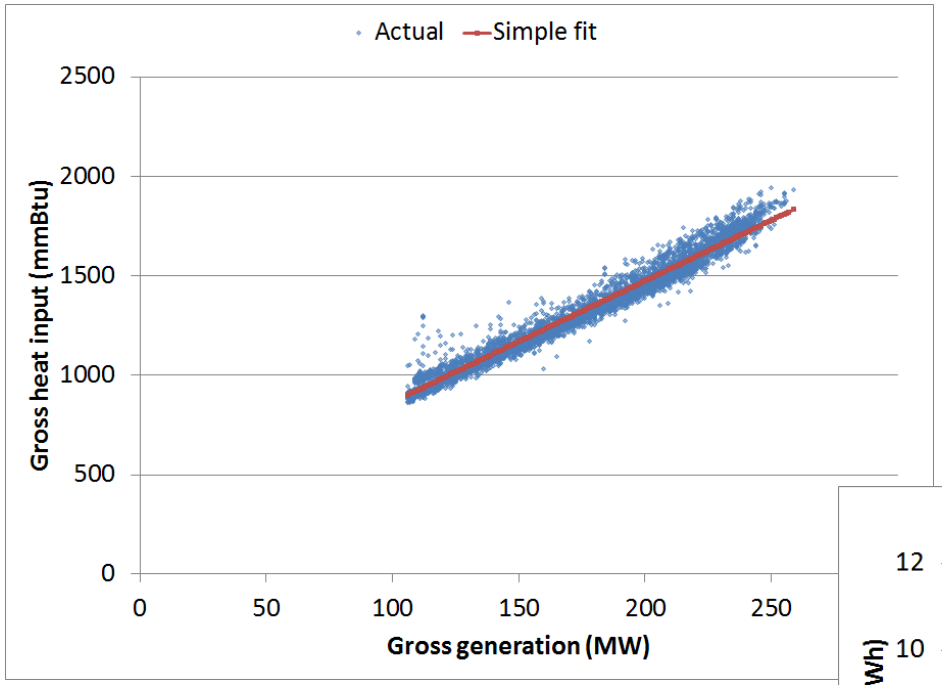


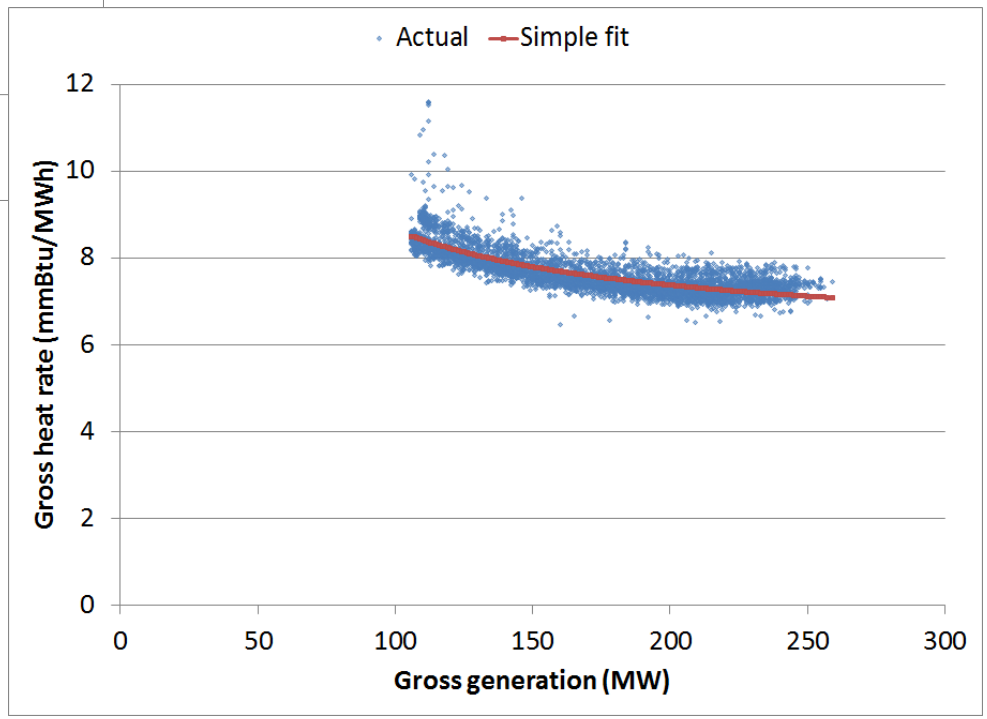
Consistency between cases

- **Constant**
  - Commitment of non-CT generators
  - Planned hourly hydro generation
  - Reserve requirements

- **Changes**
  - Interval of real-time dispatch (5-min and hourly tested)

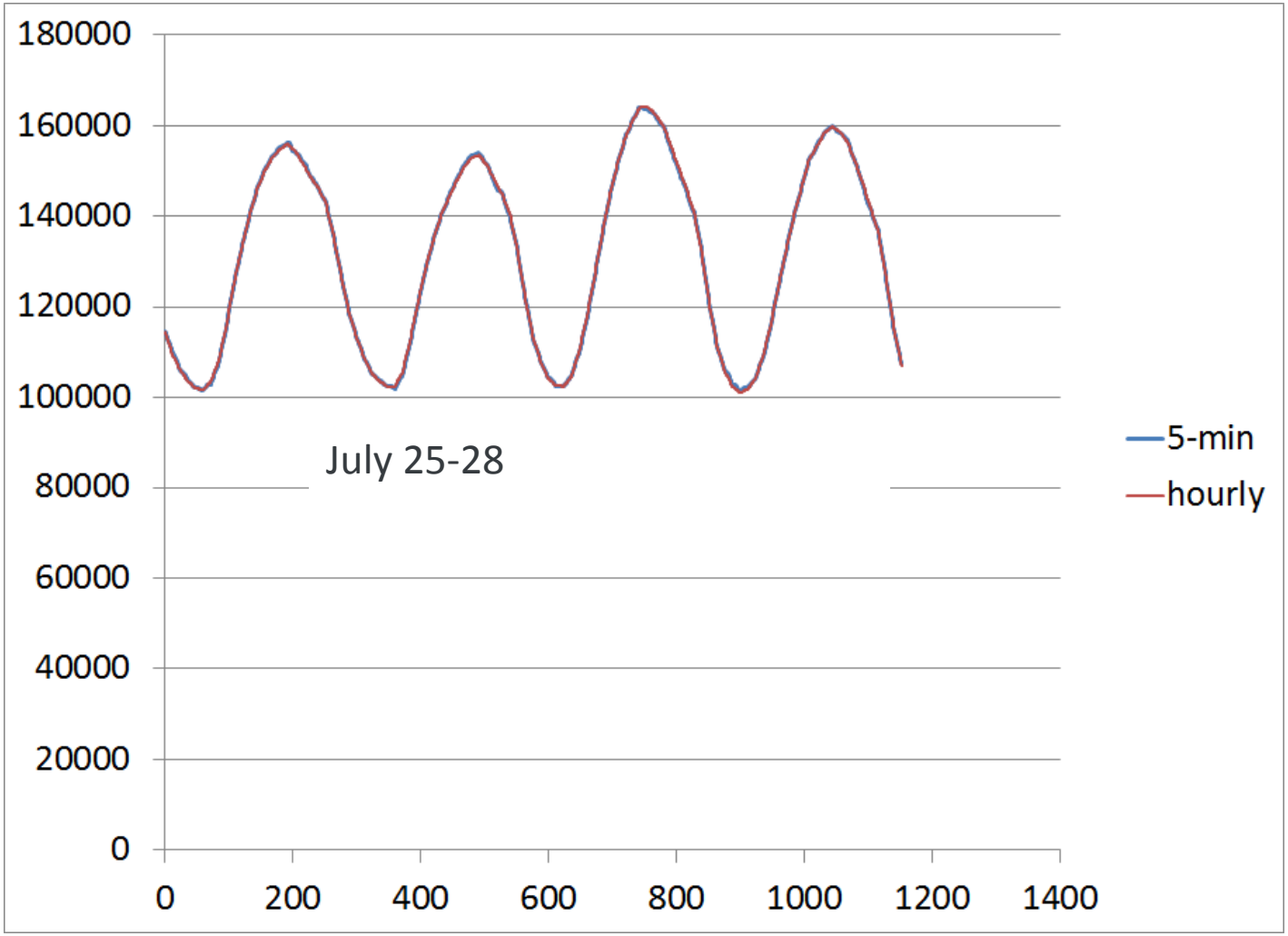
2-part heat rate curves



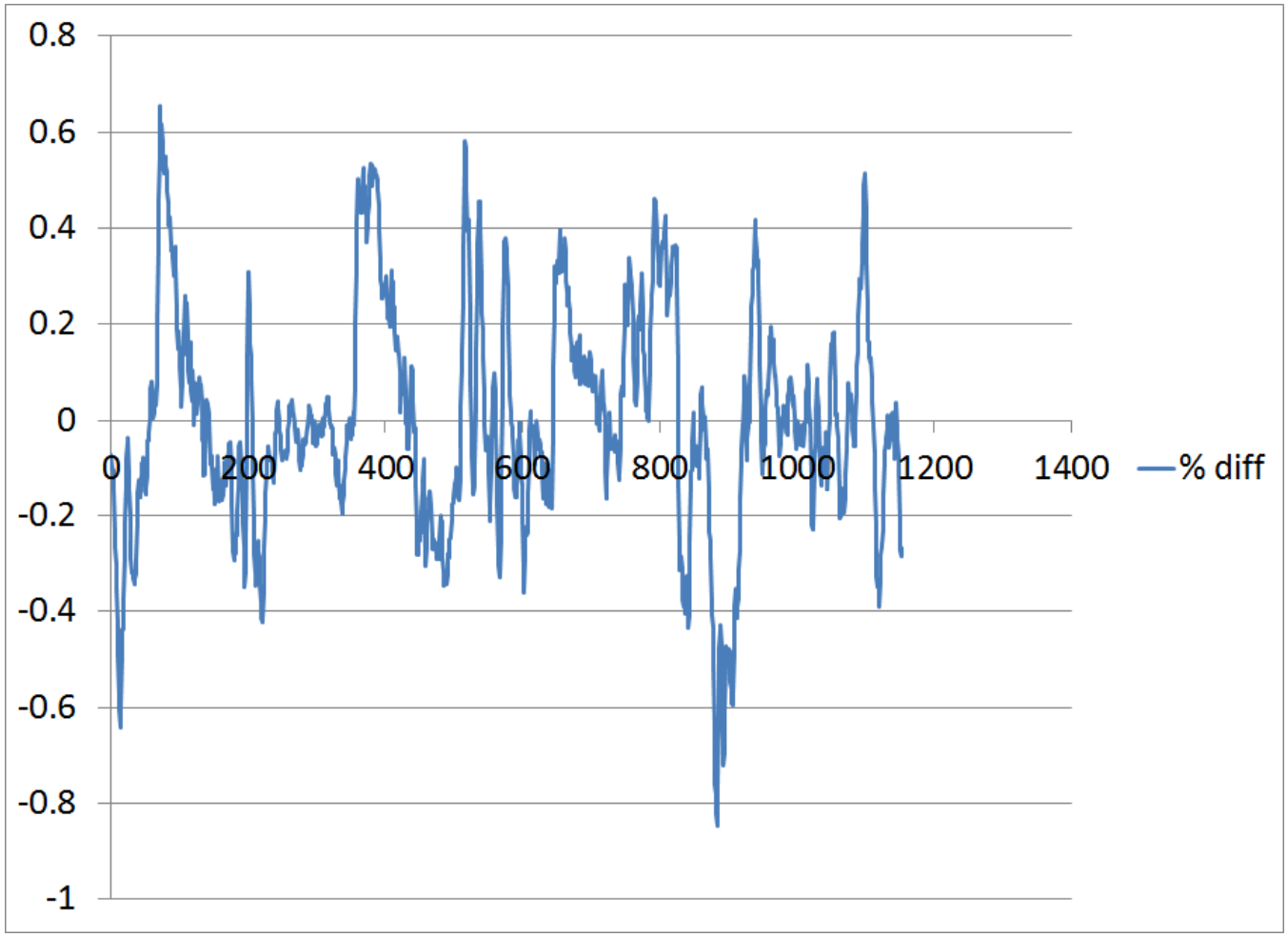


Another area of sensitivity analysis needed….

Difference between hourly and 5-min net load

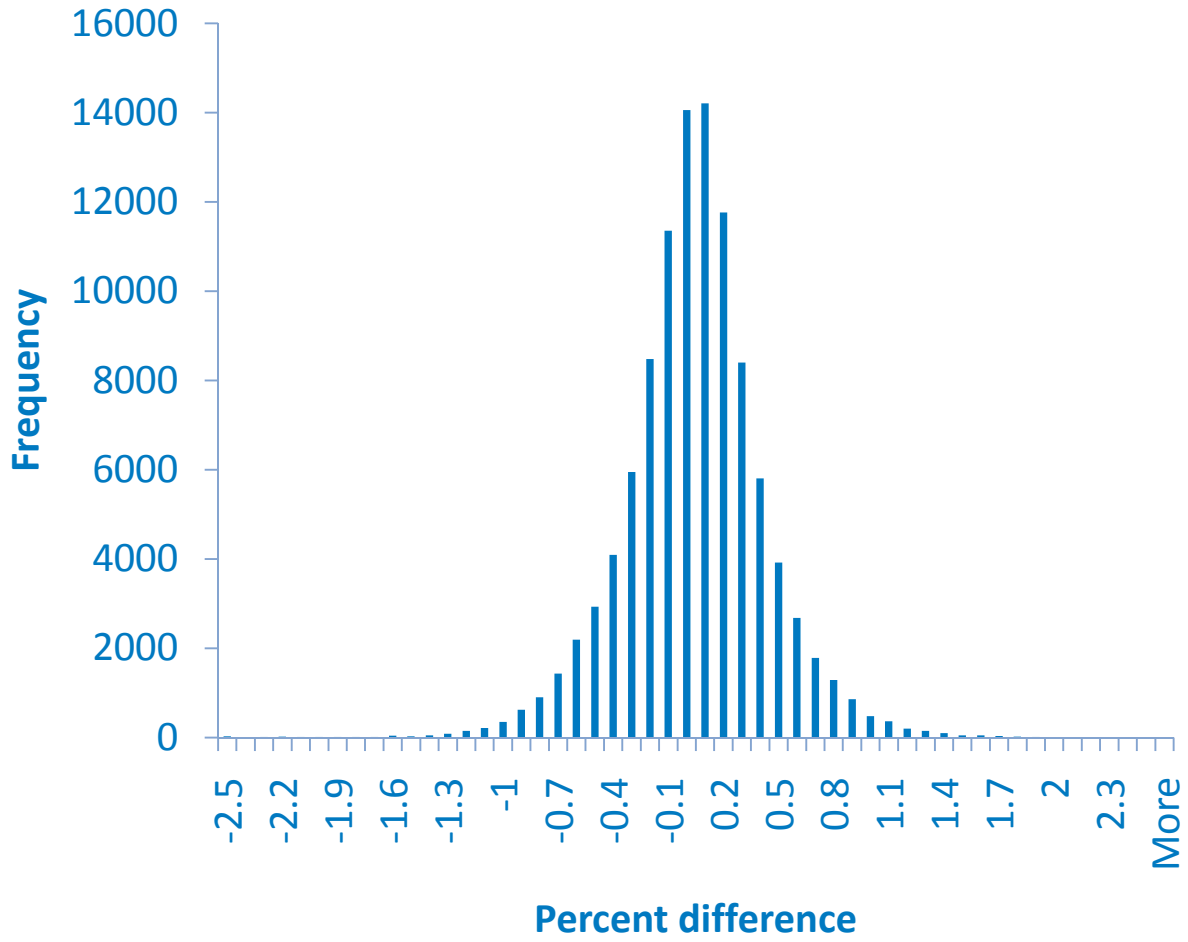


Difference between hourly and 5-min net load



5 Minute net load and interpolated hourly net load (load – mind – PV)

Difference between hourly and 5-min net load



Run Times

- **Day Ahead UC ~ 3 days**
- **4-Hour Ahead UC ~1 Day**
- **5-Minute Dispatch ~ 2 Days**
  - Approximately 12 times longer than 1-hour dispatch
  - What do we get for this increase in run time?

Results

- No unserved load
- Some change in unserved reserves
- Very little change in total production cost
- Occasionally significant change in LMPS

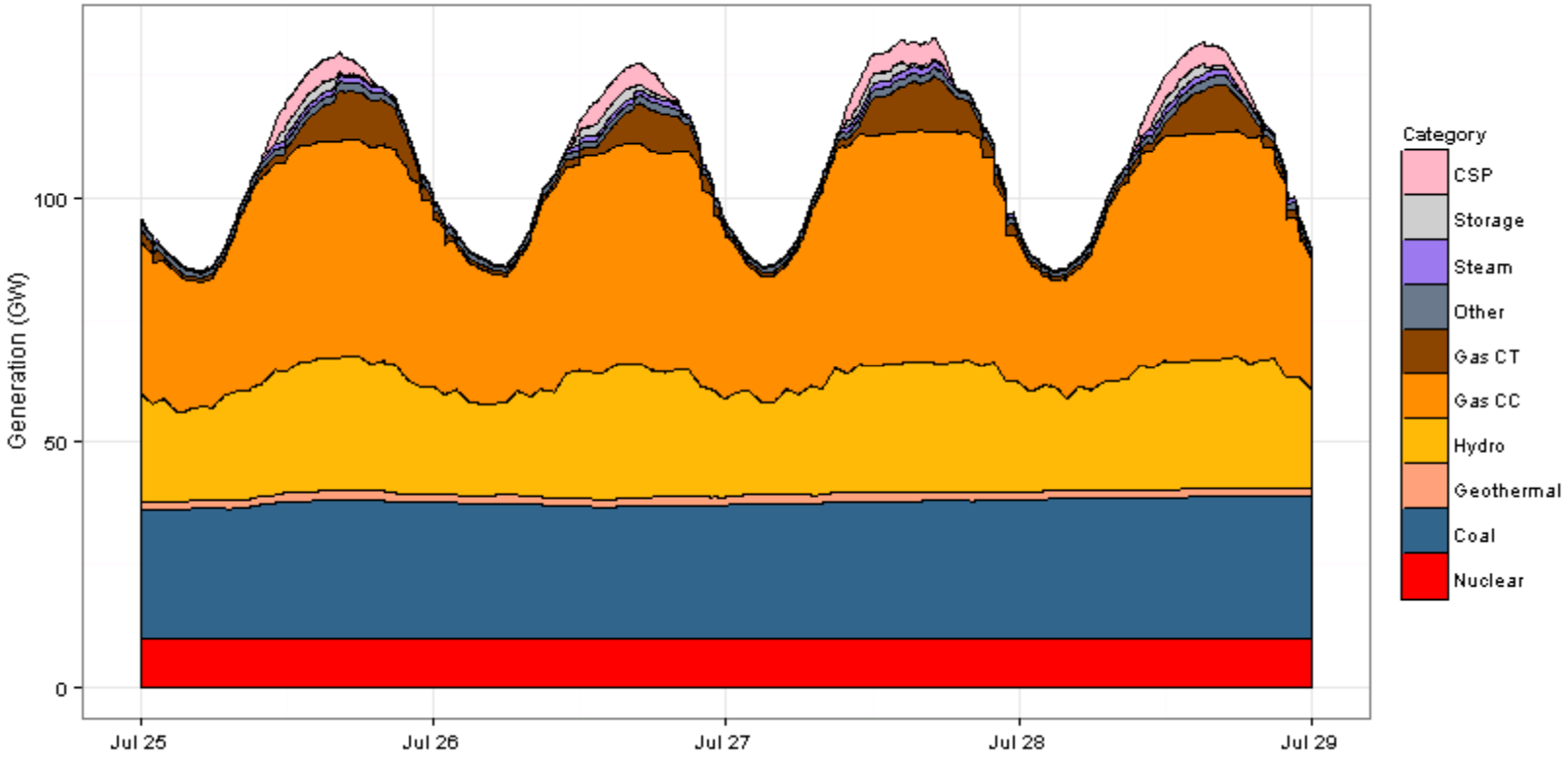
Unserved load and reserves

- No unserved load in any scenario

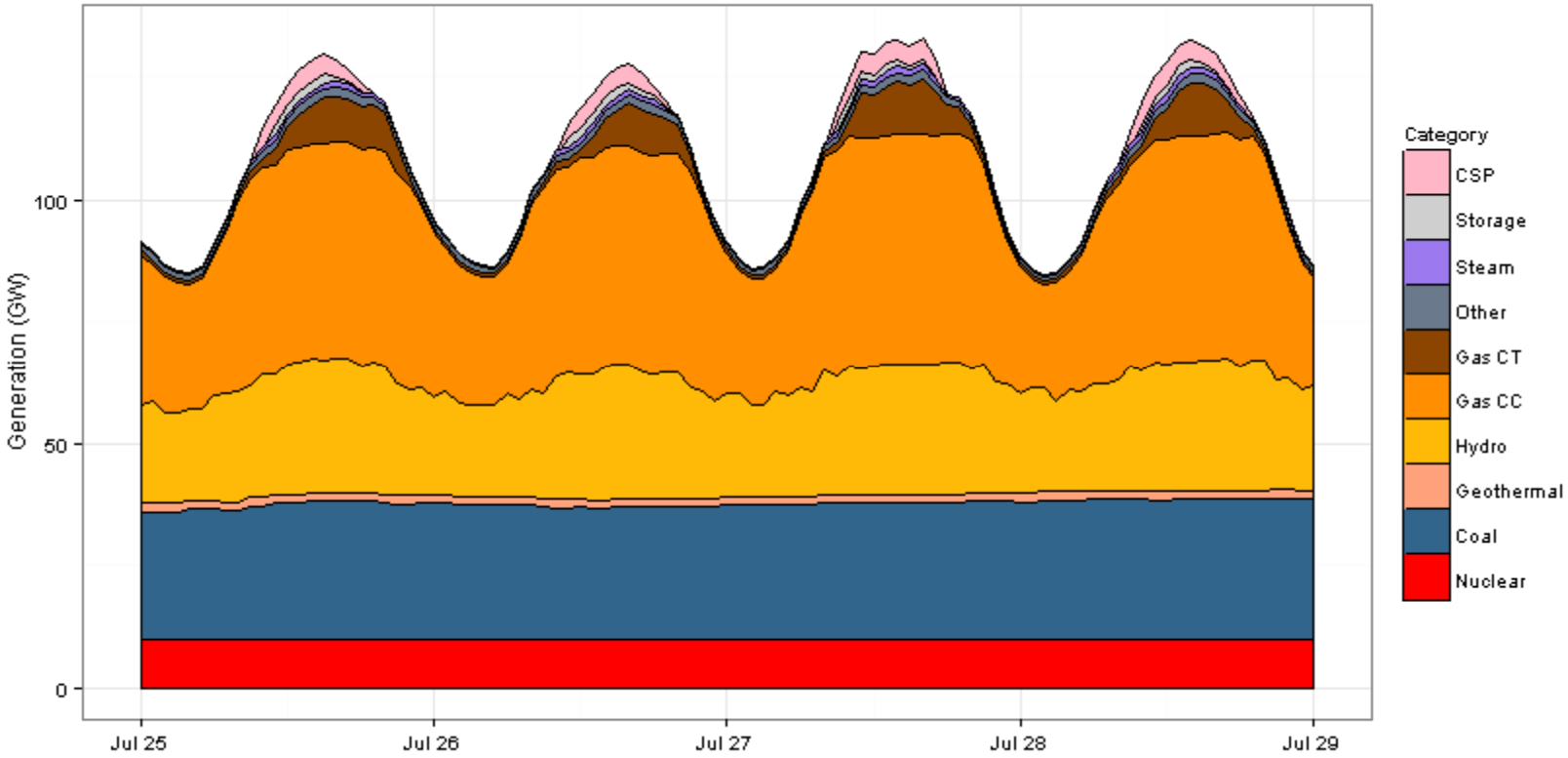
- Reserve requirement totals ~40 TW-h
- Unserved reserves

	HiMix	Reference
RT – hourly resolution	138 MW-h	178 MW-h
RT – 5-minute resolution	263 MW-h	337 MW-h (0.0008%)

5-minute resolution dispatch stack



Hourly resolution dispatch stack

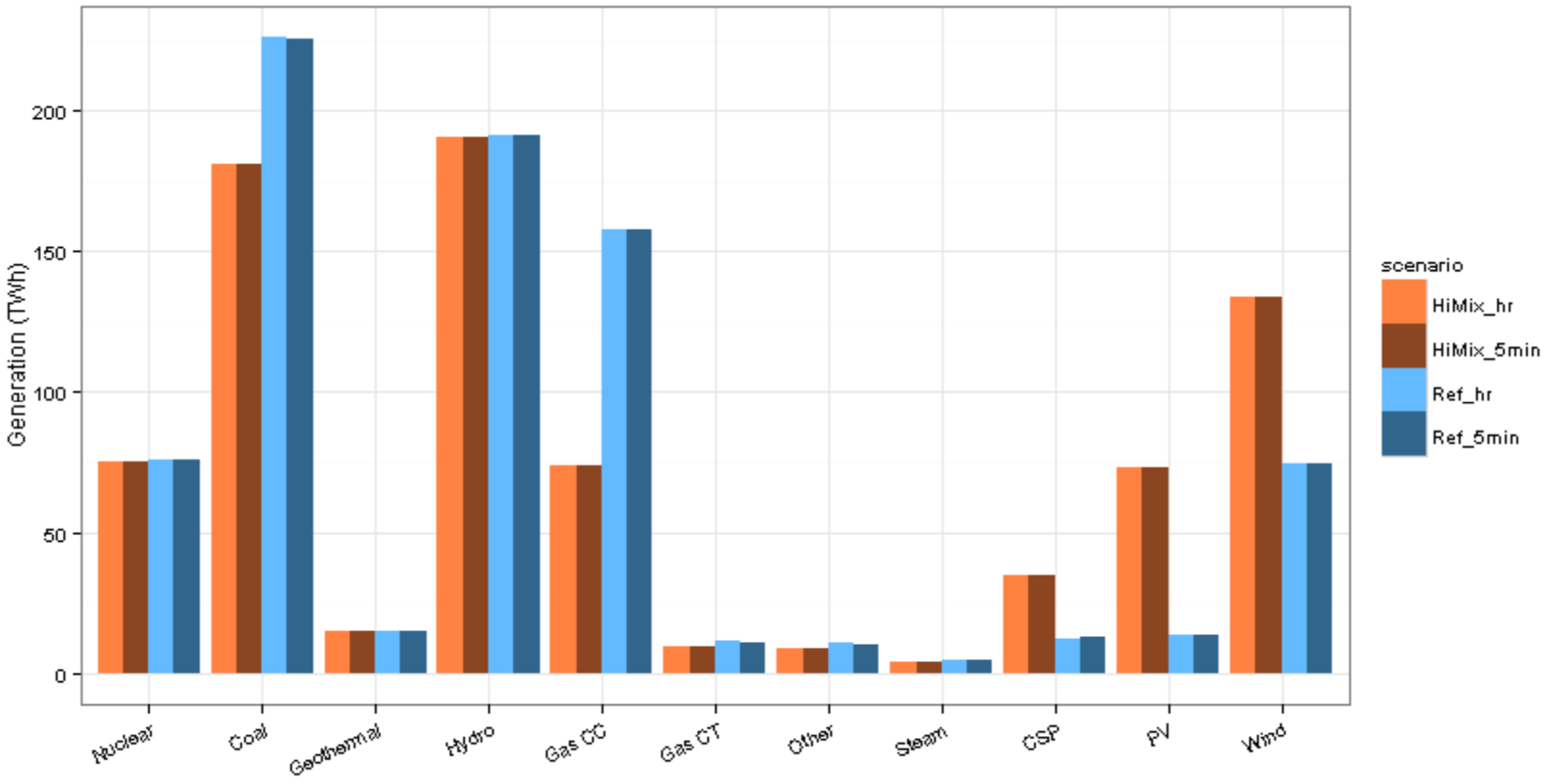


Total production costs

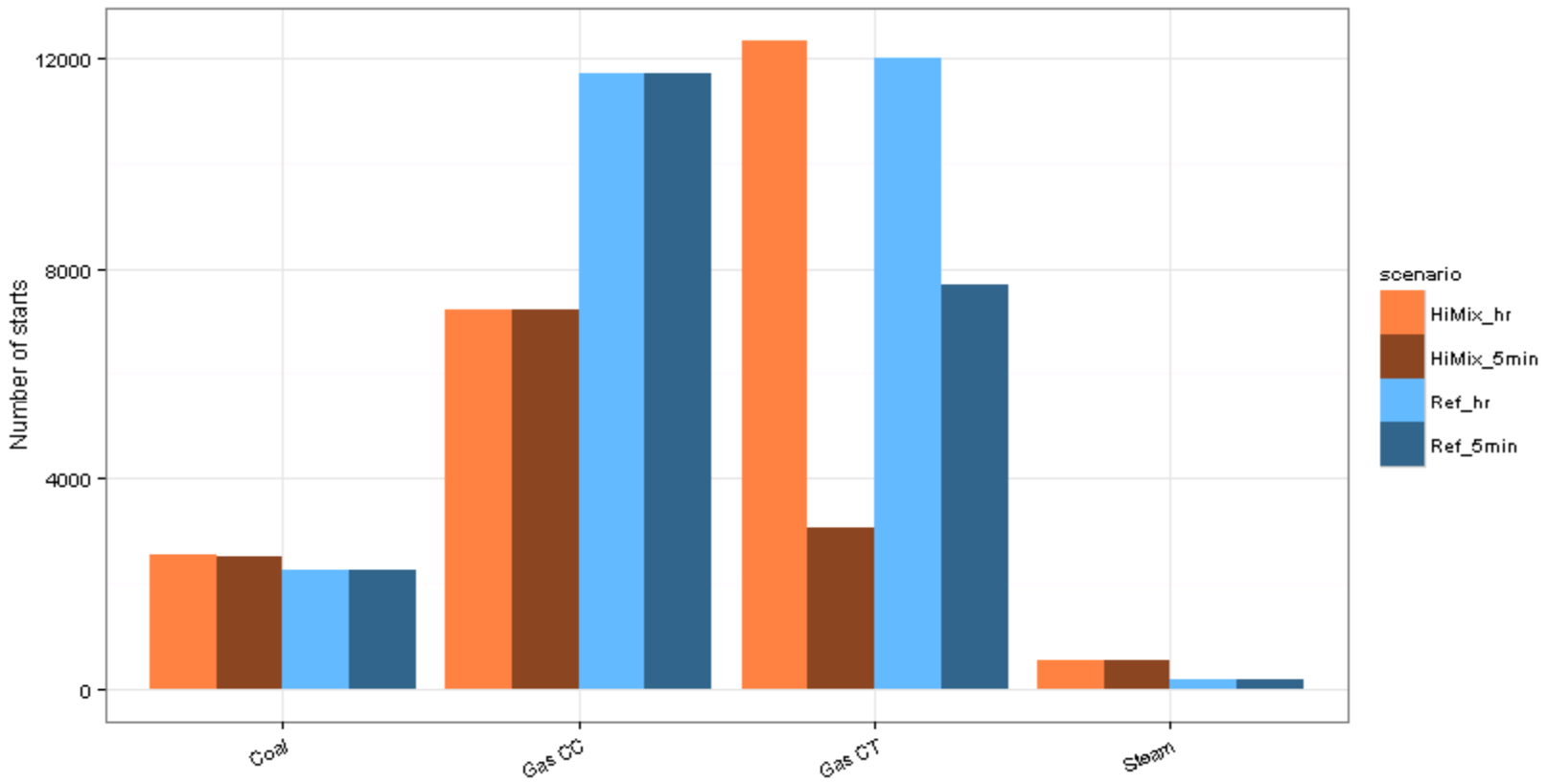
Changes in production cost between hourly and 5-min runs are within the range of uncertainty

	HiMix	Reference
RT – hourly resolution	$11.03 billion	$15.12 billion
RT – 5-minute resolution	$11.02 billion	$15.13 billion

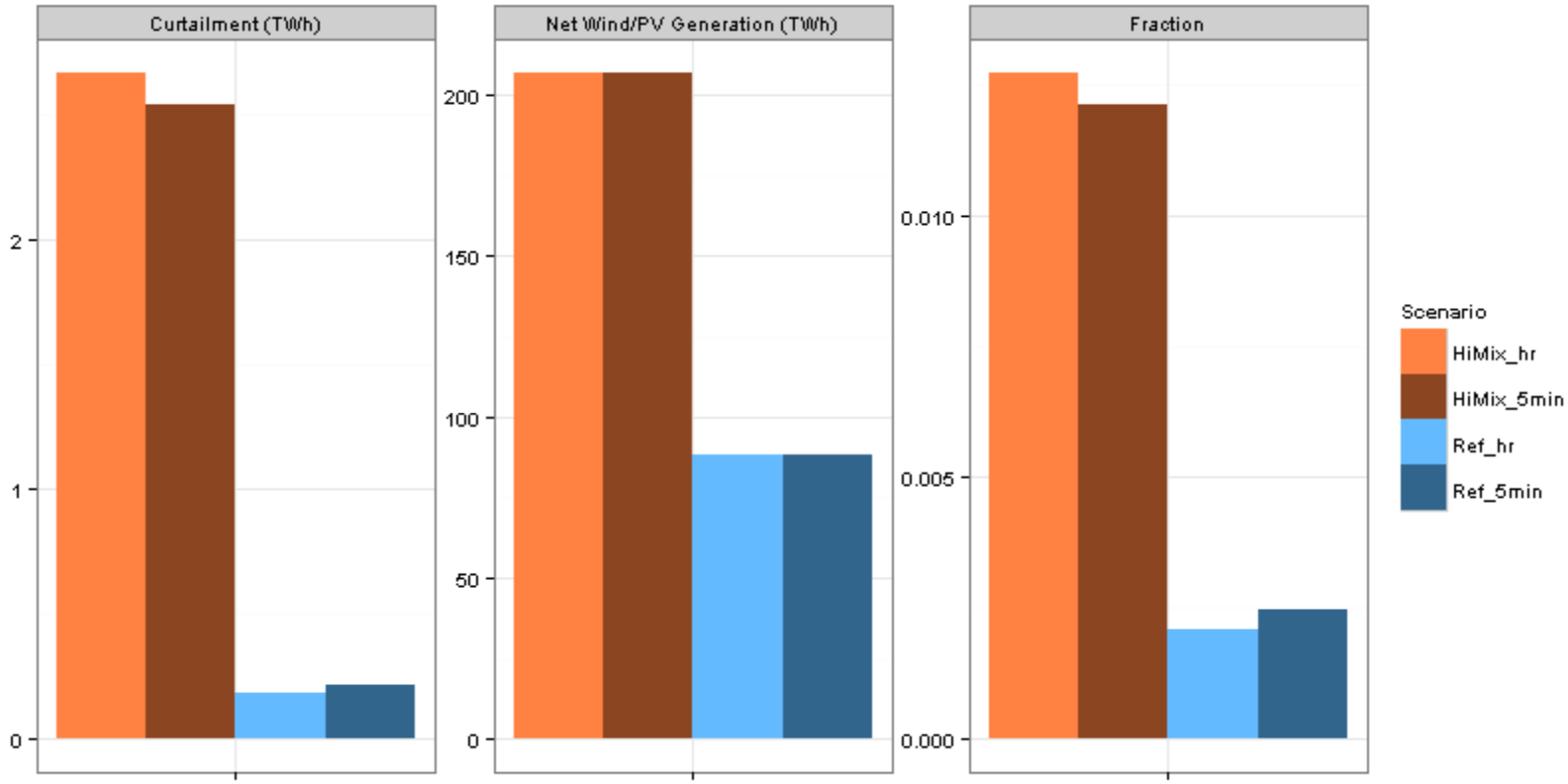
Generation by type



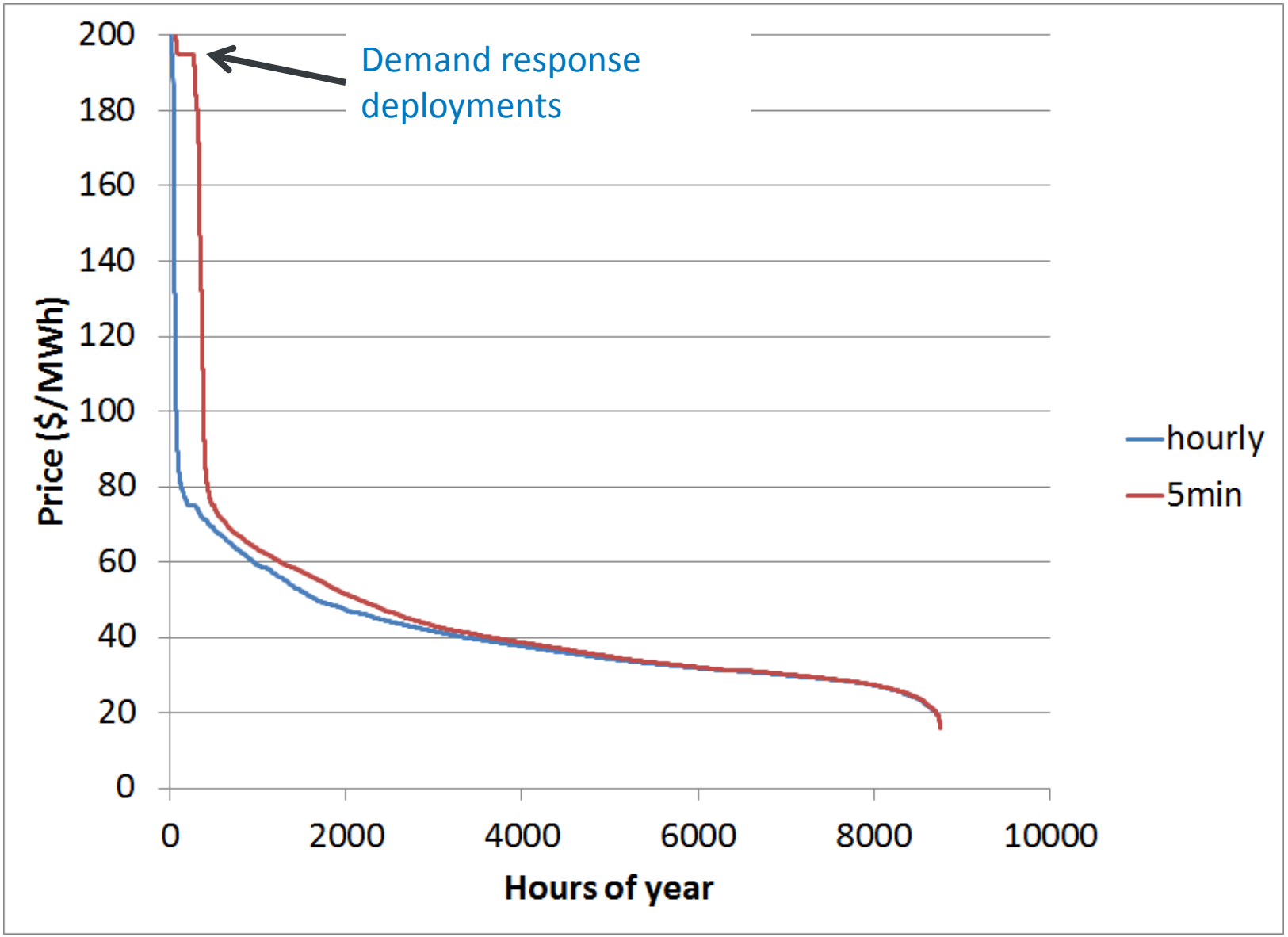
Number of starts



Curtailment



Price differences



Conclusions?

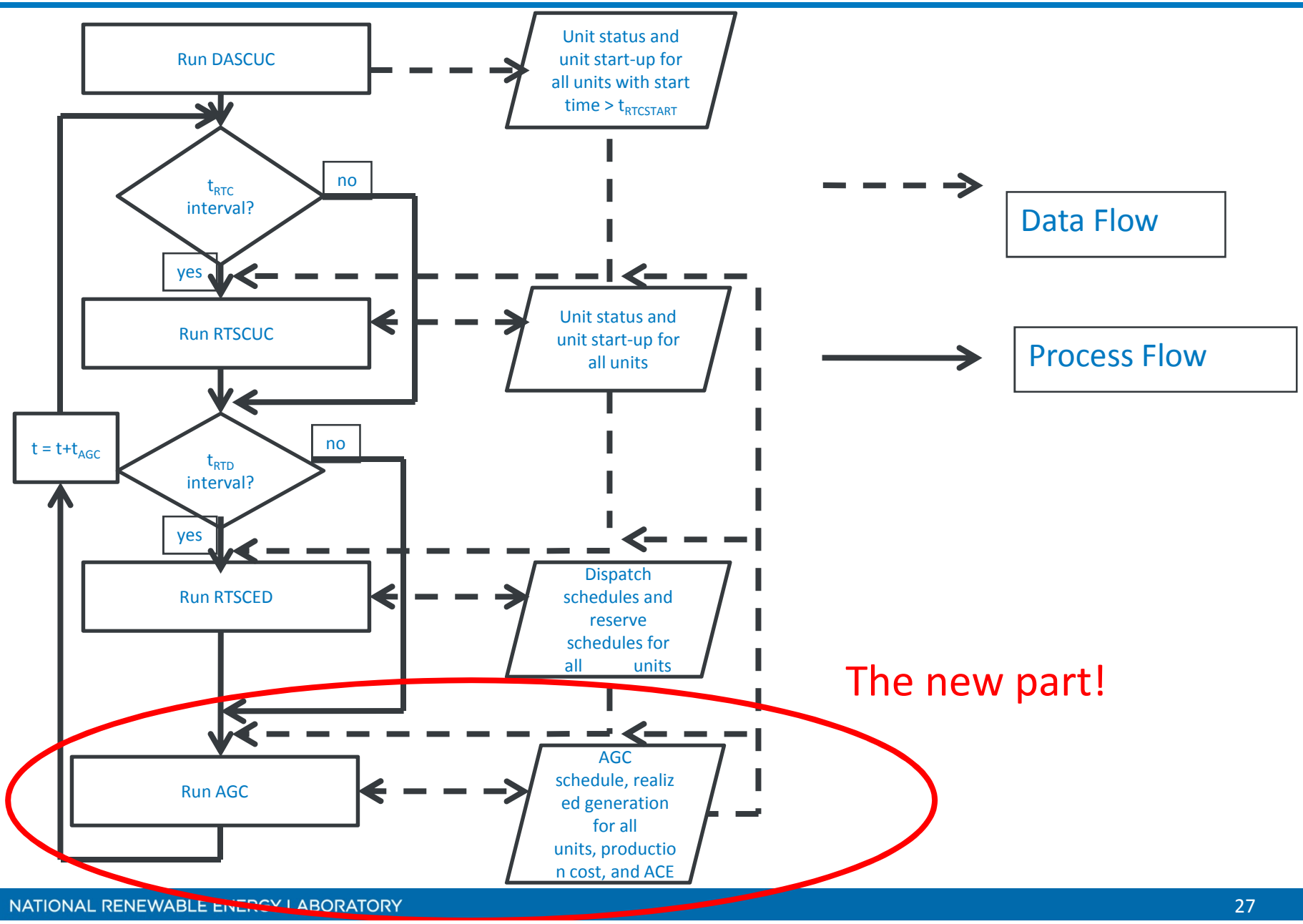
- **More analysis needed**
- **Impacts will likely be driven by system size (smaller area = more variability)**
- **May be needed to give confidence in the hourly results**
  - Subset of simulations enough? ("interesting days" approach)

Will 5-minute dispatch be enough?

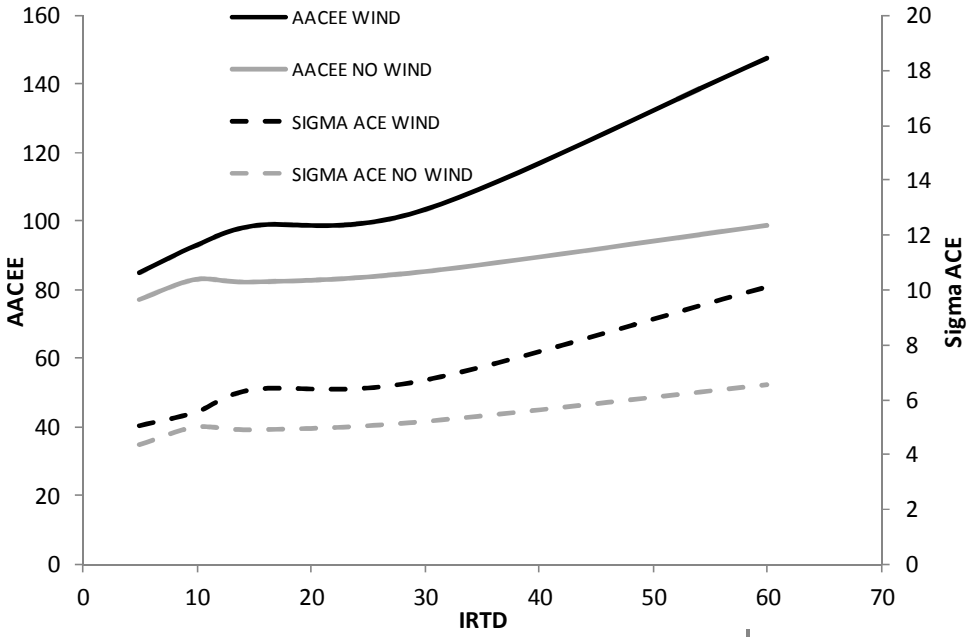
- **Of course not!**
  - Cannot model operating reserve (regulation) deployments
  - Costs of following control error ignored
- **Flexible Energy Scheduling Tool for Integration of VG**

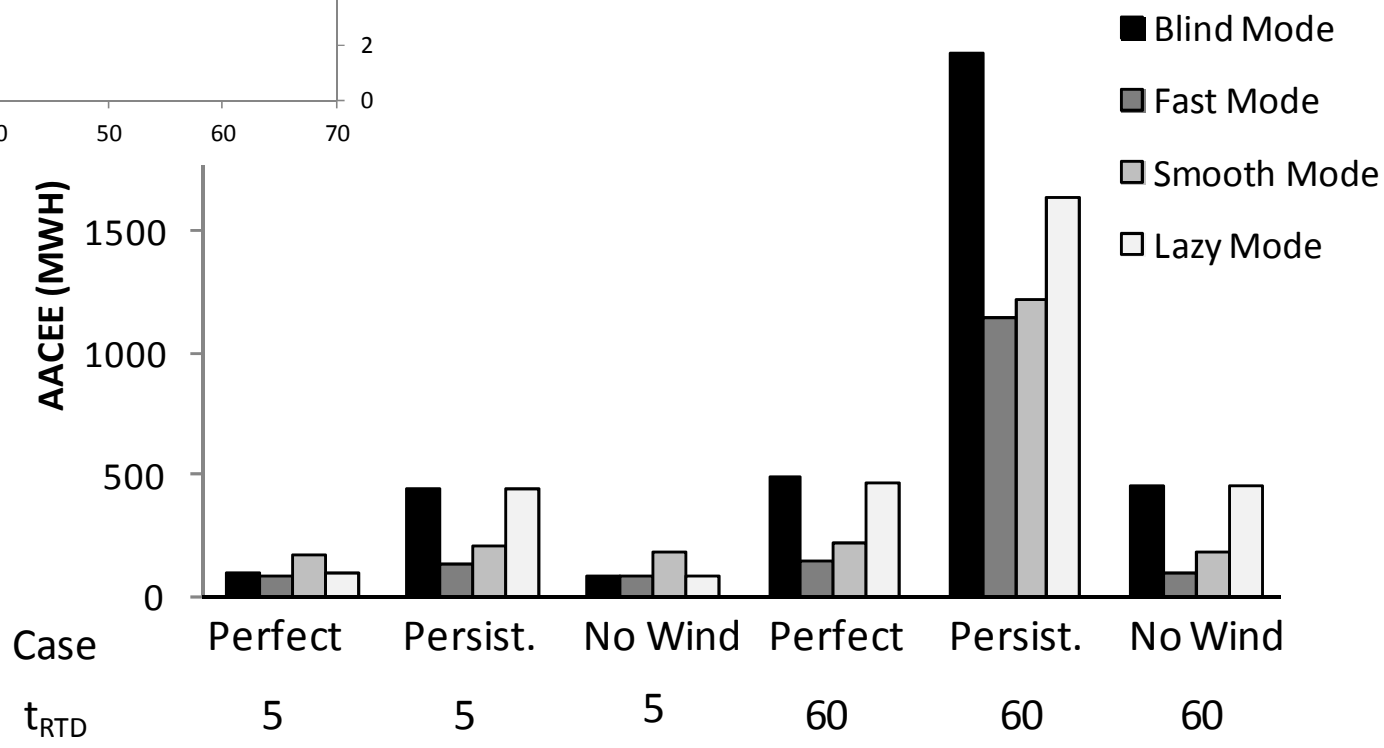
- **SCUC, SCED, and AGC sub-models**
- **Models at high resolution**
  - Typically AGC, the highest resolution at 2-6 seconds

FESTIV Flow Diagram



Impact of Scheduling and Operation on ACE





Contacts

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- **FESTIV:**
  - Erik Ela: erik.ela@nrel.gov

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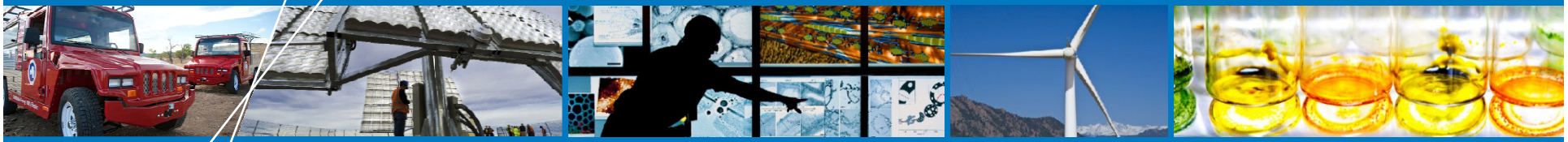

Questions?

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