



# Coordinating the Gas and Electric Power Interface

EUCI Workshop

Charlotte, North Carolina  
May 5<sup>th</sup> and 6<sup>th</sup>, 2014

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# Topics

- Historical Basis Risk
- 2013-14 Cold Snap
- Short Term Portfolio Optimization
- Stochastic Decomposition



# Historical Basis Risk

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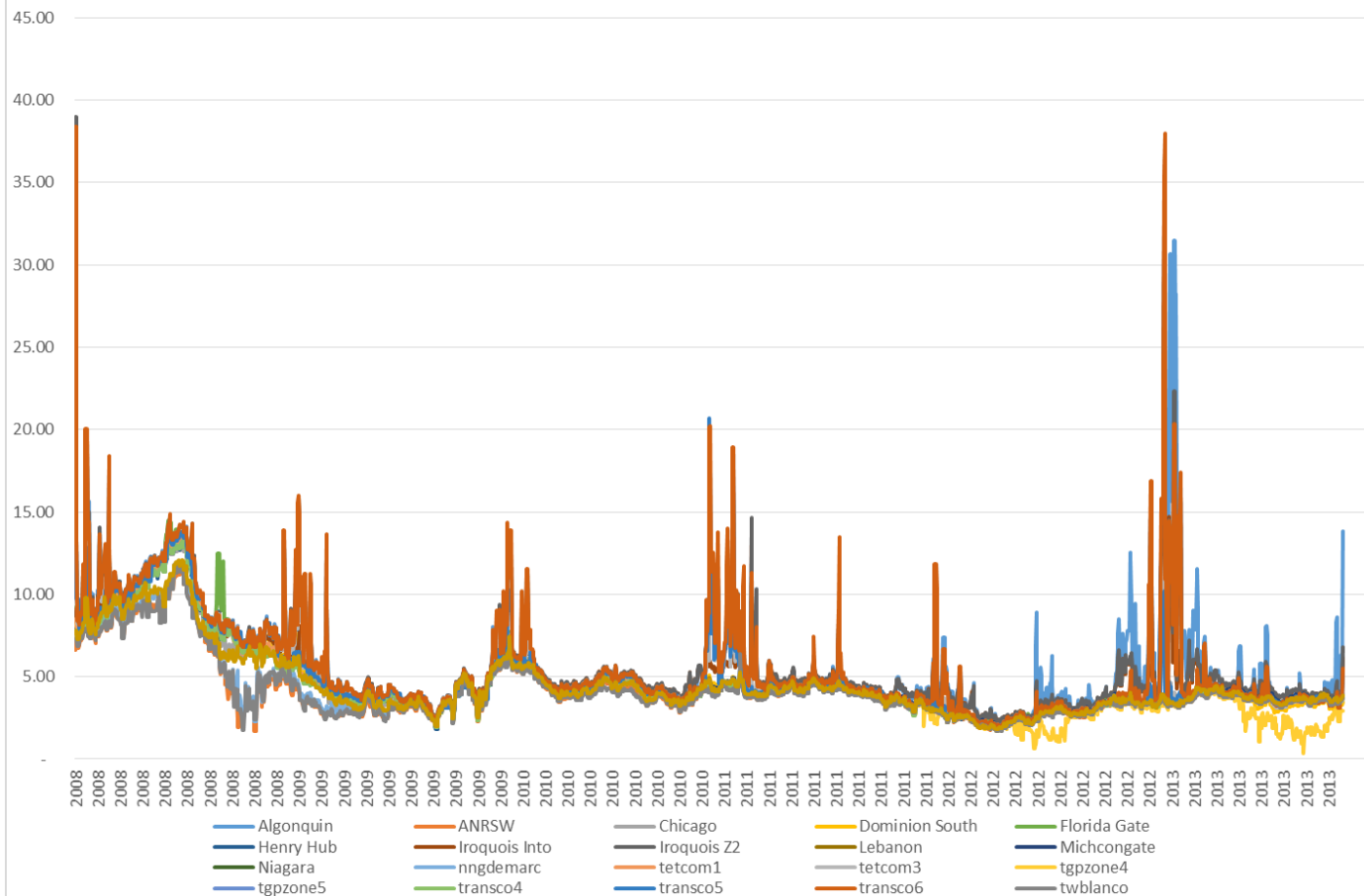
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# Daily US Natural Gas Hub Prices 2008 - 2013

OS<sup>®</sup>  
gy Model



6 May, 2014



# 2013-14 Cold Snap

Draft

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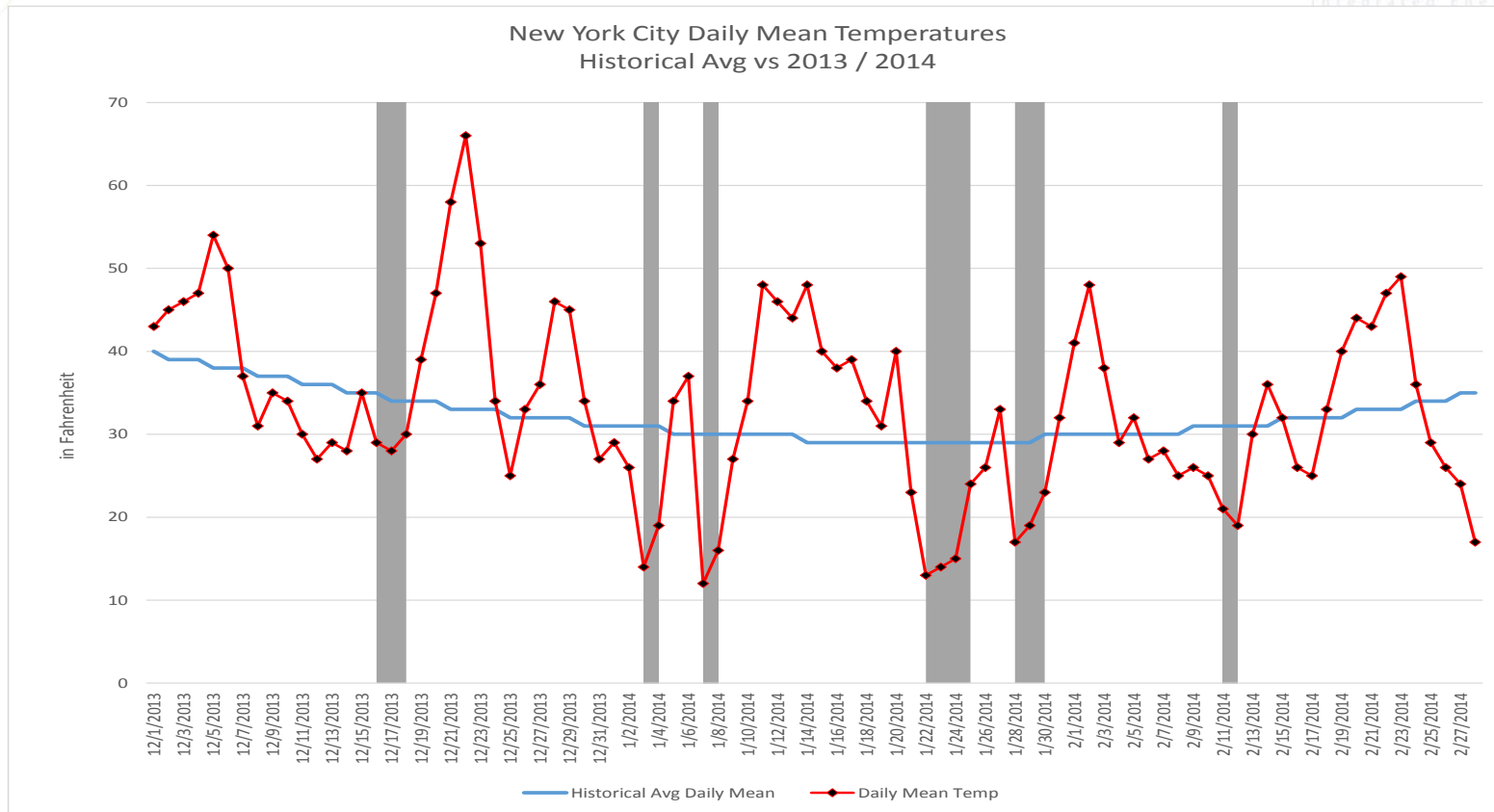
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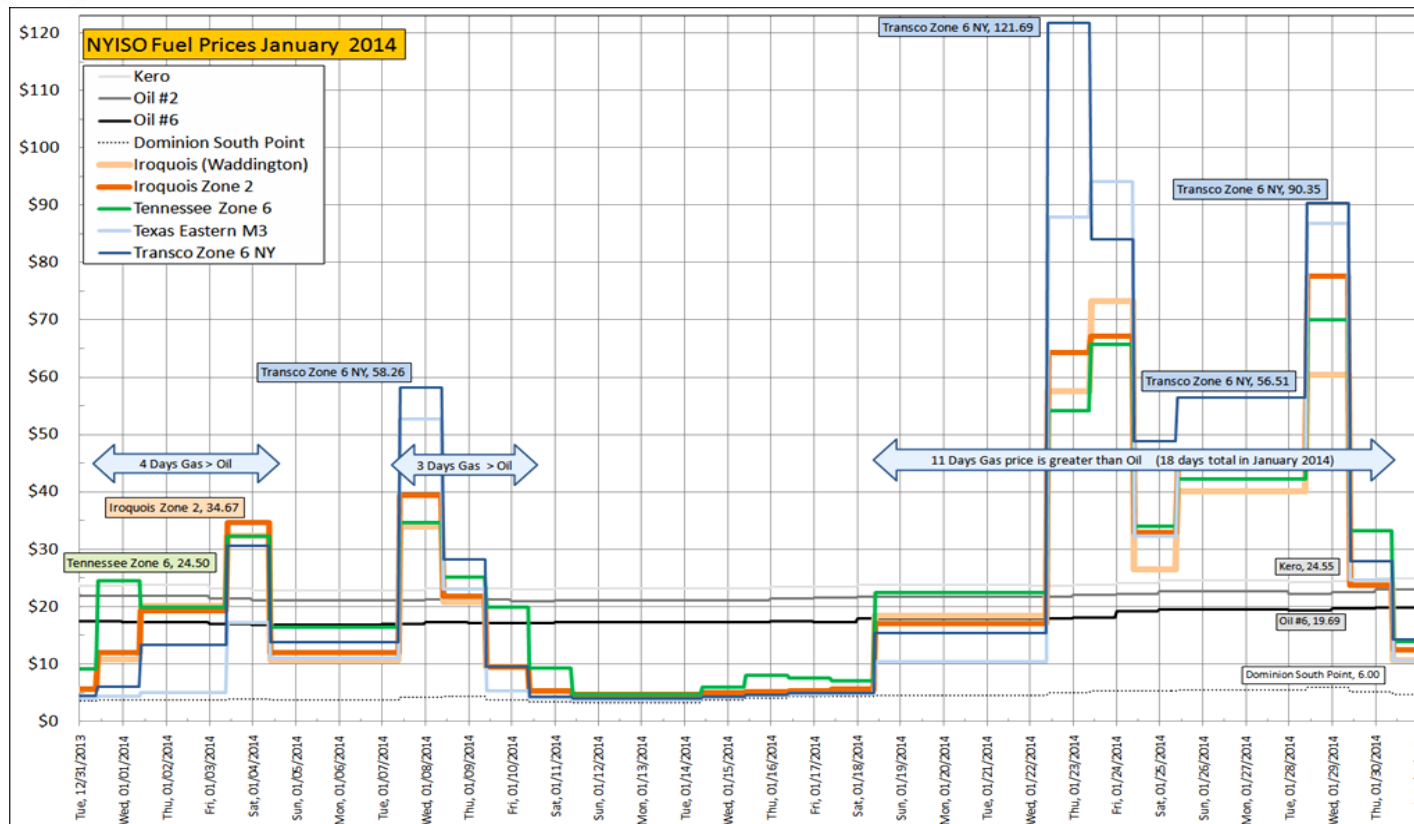
# Northeastern US Winter 2013-14

- Extensive cold periods from December to March in Northeastern US where Mean Daily temperatures dropped below 20 F
  - 16 – 18 December
  - 3 – 4 January
  - 7 – 8 January
  - 22 – 25 January
  - 28 – 30 January
  - 11 – 12 February
- Large Polar Vortex affected much of the nation in January and February 2014
- The following are summaries of the impact of natural gas supplies during the cold snap by the electrical operators ISONE, NYISO and PJM.

# Northeastern US Winter 2013-14



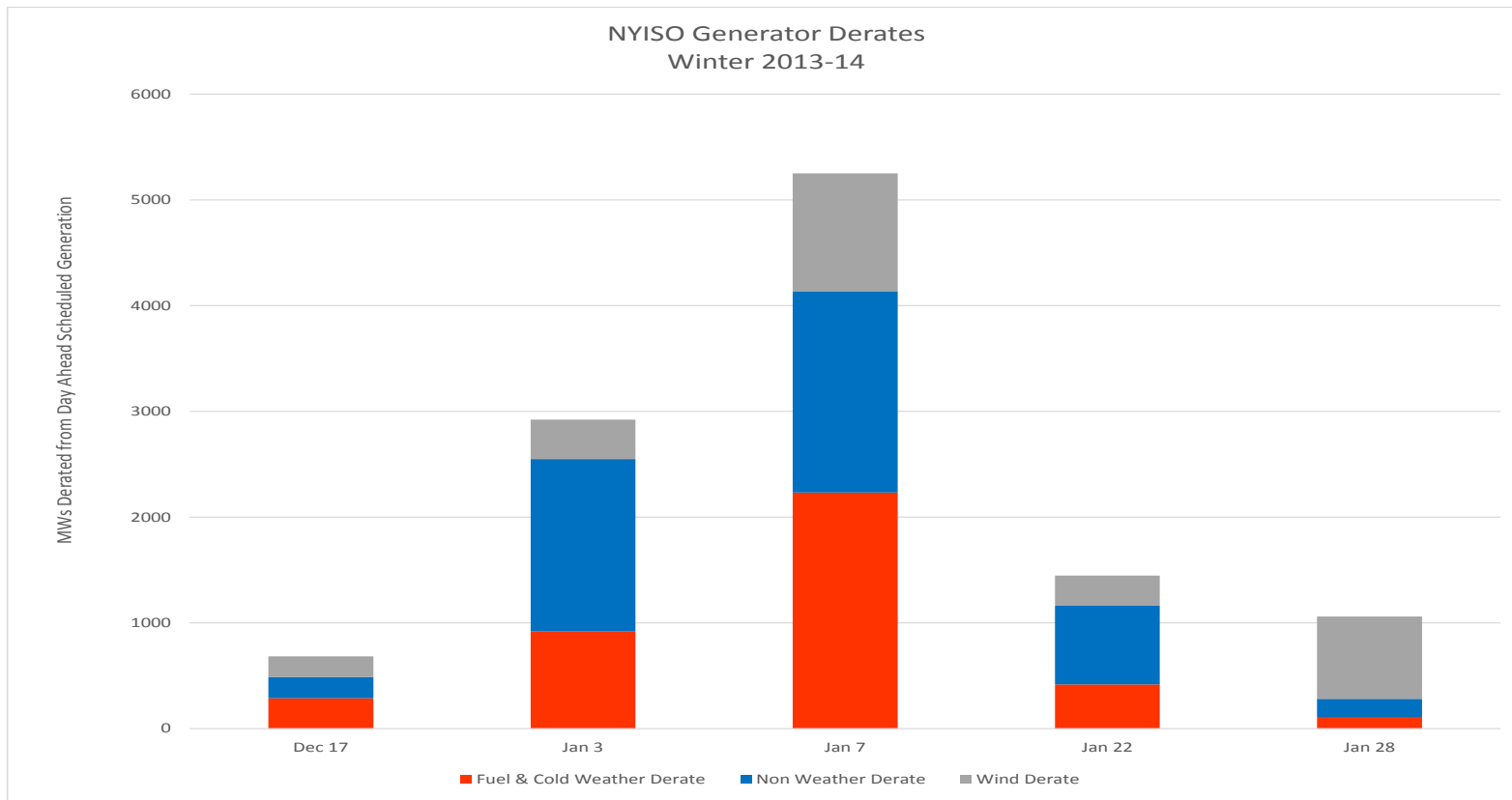
# Fuel Prices Reported by NYISO Winter 2013-14



- Natural Gas Prices Spiked above oil for 18 out of 31 days in January 2014



# NYISO Generation Derates Winter 2013-14





# January 6 - 7

- **Gas Pipelines**

- January 7, Texas Eastern declared force majeure due to a compressor failure at Delmont, PA. Gas nominations were subsequently reduced by 575,000 MMBtu's and a system wide Critical OFO was placed on all market operators in Texas Eastern Zone 3. Critical Capacity Constraint was posted by Iroquois and the Critical Day OFO posted by Tennessee Gas.

- **PJM**

- January 6, PJM reported the loss of 3,000 MW of Western Pennsylvania and Ohio generation and load conditions were 5,000 MW over forecast. At 21:00, PJM declared a NERC Energy Emergency Level 1 & 2.
- PJM was in a NERC Energy Emergency Alert Level 2 (EEA 2) on January 6 and 7 when short on Synchronized Reserves and issued a Maximum Emergency Generation Alert so all generation available could be increased to their emergency maximum output. Additionally, PJM implemented Shortage Pricing to respond to the shortage of reserves.
- January 7, PJM requested 500 MW of emergency energy from ISO-NE, from 15:00 until 23:00. ISO-NE, NYISO and PJM then coordinated the transaction to get the emergency energy delivered to New York and from New York to PJM.
- PJM set two new winter peaks on January 7, first at 8 A.M. with load reaching 138,733 MW and then again at 7 P.M., a new record was set when load reached 141,312 MW.



# January 6 – 7 (con't)

- ISONE

- During the afternoon load pickup on January 7, ISO-NE experienced 15 forced generation outages, totaling approximately 1,500 MW of capacity.
- Six natural-gas fired generators reported to ISO-NE that they were unable to affirm whether they would be able to procure fuel when called intraday during the period from January 7 – 8, 2014
- At 12:00 pm ISO-NE entered Master/Local Control Center Procedure No. 2, Abnormal Conditions Alert, due to weather in the region.
- During the peak load hour on January 7, available generation to meet load reached a low of 44 MWs, well below the 2300 MW Reserve Requirement

- NYISO

- On January 6<sup>th</sup>, Indian Point Nuclear Unit 3 tripped off-line at 21:15, derating 1050 MW.
- On January 7<sup>th</sup>, NYISO experienced 4,135 MW of generator derates over the peak hour and set a new winter peak demand of 25,738 MW. Issued a NERC Energy Emergency Alert 1 indicating that the NYISO just meeting reserve requirements and public appeals for customers to curtail non-essential use.



# January 20-24

- **Gas Pipelines**
  - Many of the gas pipelines to the Northeastern US were running near full capacity.
- **NYISO**
  - On January 21 the NYISO requested a temporary waiver from the FERC of the current offer rules in order to pay suppliers, in the form of a BPCG, if they incurred actual costs in excess of the \$1,000/MWh offer cap. The FERC granted this request and the waiver was effective January 22 – February 28.



# January 27-31

- **Gas Pipelines**
  - Many of the gas pipelines to the Northeastern US were running near full capacity.
- **NYISO**
  - On Friday, January 24, information provided by some generator owners indicated the possibility of full oil depletion by Monday, January 27, and predicted an inability to purchase gas over January 27-28 time periods.
  - There were some instances of reported difficulty receiving fuel deliveries (barges and trucks) as well as difficulties purchasing certain fuels that meet permit requirements. NYISO did schedule additional out-of-merit actions due to the uncertainty of oil deliveries and the uncertainty of nominating gas.
- **ISONE**
  - On January 28, the system had total gas-fired capability (“Capacity Supply Obligation” or “CSO”) of more than 11,000 MW – but gas generators produced only about 3,000 MW during the peak hour



# NYISO Fuel Impacts

- Gas Generators in New York connected to an interstate pipeline fared better than generators connected to an LDC network
  - Most gas generation in New York City and Long Island are behind the City-gate and must rely deliveries through the LDC.
  - There were many instances where the Gas LDCs declared OFO's which reduced daily balancing and required hourly burn limitations.. This in turn reduced flexibility in electric operations.
  - In New York, generators connected directly to the interstate pipelines with confirmed gas nominations were successful generating on gas to their schedules, including during times of declared Operational Flow Orders (OFOs) or System Alerts
  - Gas-only generation connected to interstate pipelines and east of the Central East interface were not economically scheduled during the five cold snaps periods due to the extremely high gas prices, but were capable of securing gas in response to the ISOs supplemental requests for generation
- There were periods where the heavy use of oil significantly reduced available supplies in the Northeast
- In New York, oil supplies became difficult at the tail of the cold snap.
  - January 22 - 29, a few oil-only and dual fuel units were not able to keep up with oil replenishment rates in their oil deliveries.



# ISONE Fuel Impacts

- Gas pipelines were constrained even without significant use by gas-fired generators in New England
  - Most of the New England pipelines were operating at or near capacity, with some recording record throughputs.
  - However much of the ISO-NE gas fleet was either off line due to economics or burning alternate fuel.
  - On January 7 at the peak of the cold snap, only 3,995 MW of gas generation was supplied by natural gas and no gas generators connected to Tennessee Gas Pipeline were using natural gas.
- There were periods where the heavy use of oil significantly reduced available supplies in the Northeast
- In ISONE, oil fired generators reported difficulty in replenishing fuel inventory due to
  - Unavailability of oil
  - Increased demand for oil from both heating and power sectors
  - Fuel Oil No. 6 is not readily available on short notice
  - Following diminishment of oil generation in recent years
  - Difficulty securing barge transportation throughout the Northeast due to weather and inability to transport through shallow areas
  - Trucks were limited, as were hours for truck drivers



# PJM Fuel Impacts

- Coal Icing
  - PJM received reports of coal quality issues related to the heavy rains during the weekend prior to January 6th, and then subsequent icing of coal and coal related equipment during the Jan 6-9 period.
  - There were some forced outages related to coal quality but the majority of coal quality issues resulted in unit de-rates.
- Natural Gas
  - PJM had up to 9,000 MW of natural gas outages due to natural gas curtailments through January 6 – 8.



# Price Impacts

- Natural Gas prices exceed oil prices for large portions of the winter in the Northeastern US, as congestion on the natural gas pipelines network increased the spot price of natural gas.
- As such, oil derivatives became the marginal fuel for both NYISO and ISONE for much of the winter as natural gas prices exceeded oil significantly.
- There were periods where the heavy use of oil significantly reduced available supplies in the Northeast
- In New England, this resulted in significantly higher LMPs for the first three months of 2014
  - 64% of average daily real-time prices were above \$ 100, in contrast with past years (e.g., 28% in 2012-13 winter)
  - For the first time in more years than 10 years, average daily real-time prices exceeded \$250 (9 times)
  - Energy market costs were \$5.05B this winter, in contrast to \$5.2B for all of 2012
- In New York
  - Load weighted electric LBMP for January was \$183/MWh, 176% increase over December 2013
  - Natural gas prices (as indexed at Transco Zone 6 for NYC area) averaged \$27.43/MMBTU, nearly 400% increase over December 2013



# Short Term Portfolio Optimization

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# Solving Unit Commitment and Economic Dispatch using MIP

PLEXOS®  
Integrated Energy Model

Unit Commitment and Economical Dispatch can be formulated as a linear problem (after linearization) with integer variables of generator on-line status

*Minimize Cost = generator fuel and VOM cost + generator start cost  
+ contract purchase cost – contract sale saving  
+ transmission wheeling  
+ energy / AS / fuel / capacity market purchase cost  
– energy / AS / fuel / capacity market sale revenue*

*Subject to*

- *Energy balance constraints*
- *Operation reserve constraints*
- *Generator and contract chronological constraints: ramp, min up/down, min capacity, etc.*
- *Generator and contract energy limits: hourly / daily / weekly / ...*
- *Transmission limits*
- *Fuel limits: pipeline, daily / weekly / ...*
- *Emission limits: daily / weekly / ...*
- *Others*



# Dispatch Optimization

- Dispatch to Demand
  - Energy Price Formation
  - Ancillary Services Price Formation
- Dispatch to Price
  - Energy Price for Each Unit in Portfolio
  - Fuel Prices
  - Ancillary Prices for BM
- Dispatch to Load Sell Excess to Market



# Daily

- Daily 24hr Fuel Offtakes
- Daily 24hr of Emissions
- Daily 24hr of Energy Revenues
- Daily 24hr of Costs
- Daily 24hr of Ancillary Revenues
- Daily 24hr of Sales to Market
- Daily 24hr of Demand Payments



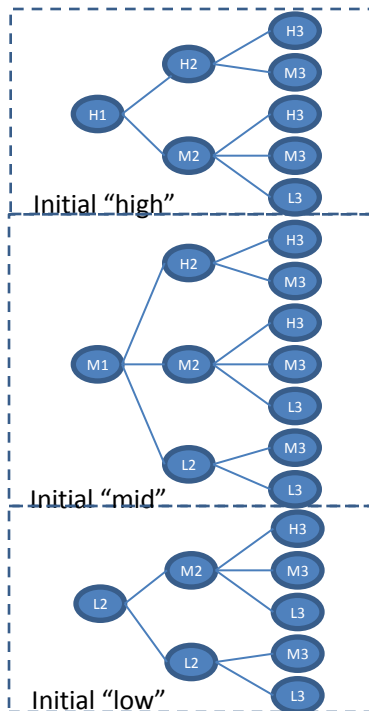
# Stochastic Optimization (SO)

- Fix perfect foresight issue
  - Monte Carlo simulation can tell us what the optimal decision is for each of a number of possible outcomes assuming perfect foresight for each scenario independently;
  - It cannot answer the question: what decision should I make now given the uncertainty in the inputs?
- Stochastic Programming
  - The goal of SO is to find some policy that is feasible for all (or almost all) of the possible data instances and maximize the expectation of some function of the decisions and the random variables
- Scenario-wise decomposition
  - The set of all outcomes is represented as “scenarios”, the set of scenarios can be reduced by grouping like scenarios together. The reduced sample size can be run more efficiently

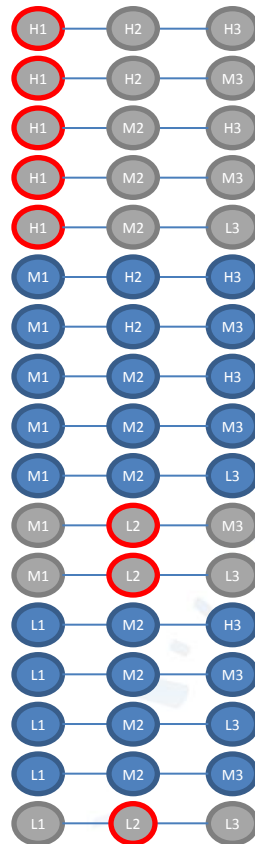


# Stochastic Variables

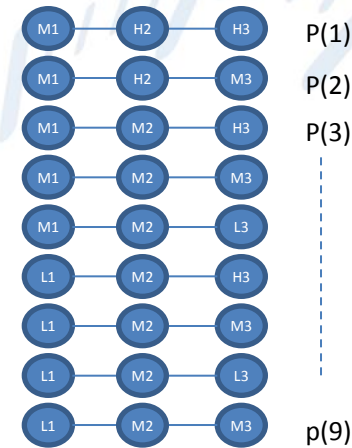
- Set of uncertain inputs  $\omega$  can contain any property that can be made variable in PLEXOS:
  - Load
  - Fuel prices
  - Electric prices
  - Ancillary services prices
  - Hydro inflows
  - Wind energy, *etc*
- Number of samples  $S$  limited only by computing memory
- First-stage variables depend on the simulation phase
- Remainder of the formulation is repeated  $S$  times



Initial Problem



Scenarios



Sample Reduction



# Day-ahead Unit Commitment, Continued

Stochastic Optimisation:

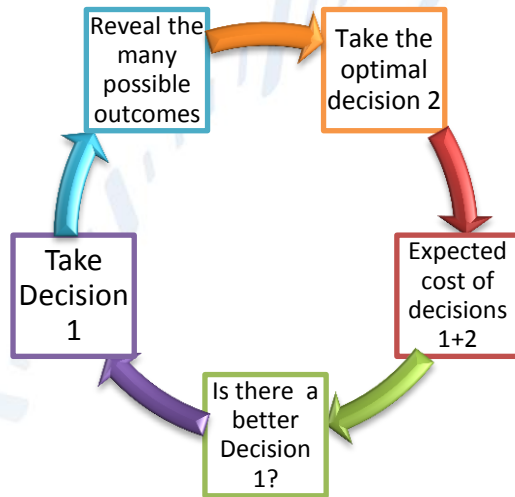
Two stage scenario-wise decomposition

**Stage 1:**

Commit 1 or 2 or none of the generators

**Stage 2:**

There are hundreds of possible uncertainty paths. For uncertainty path decide the optimal commitment of the other units and dispatch of all units

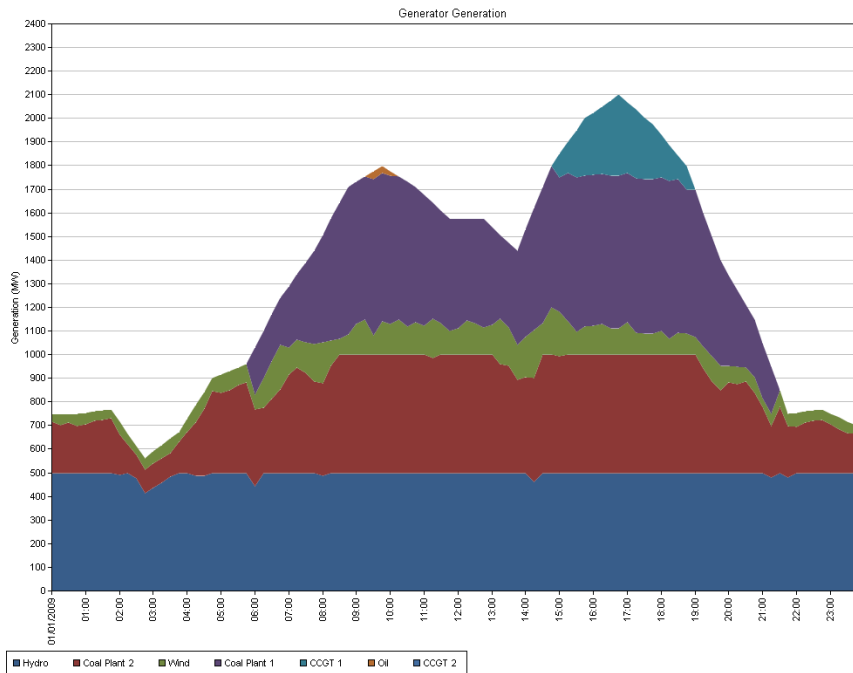


RESULT: Optimal unit commitment for generators

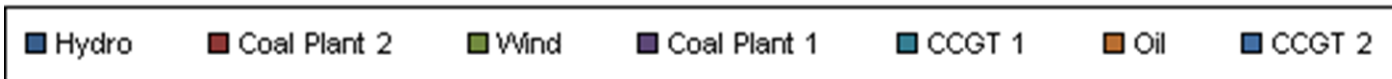


# PLEXOS Base Model Generation Result

PLEXOS®  
Integrated Energy Model

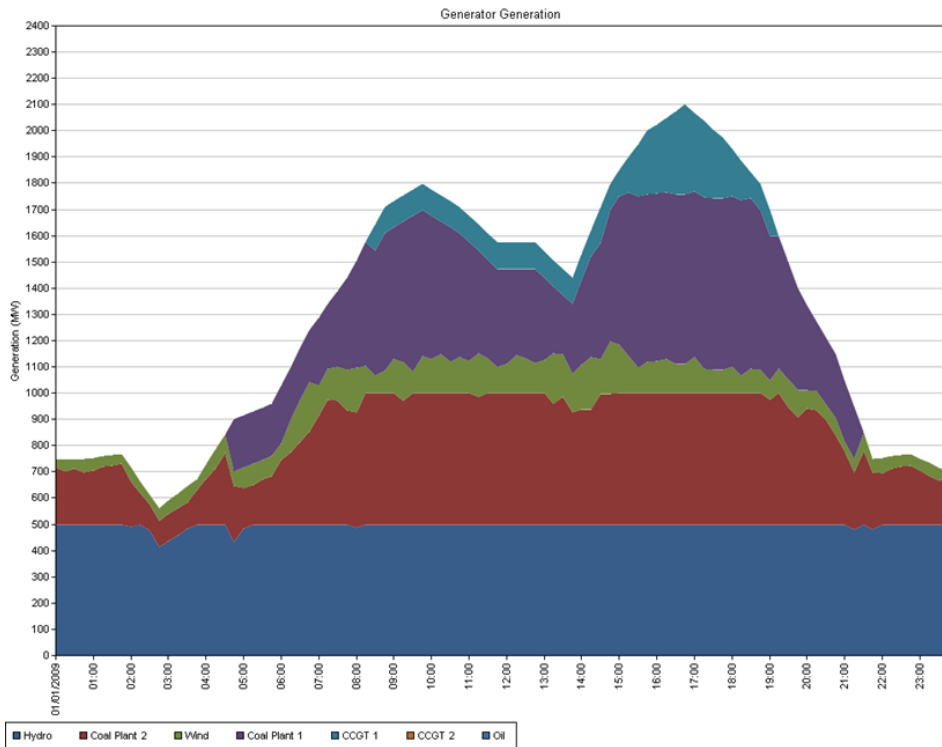


- Peaking plant in orange operating at morning peak
- Some displacement of hydro to allow for ramping
- Variable wind in green





## Spinning Reserve Requirement

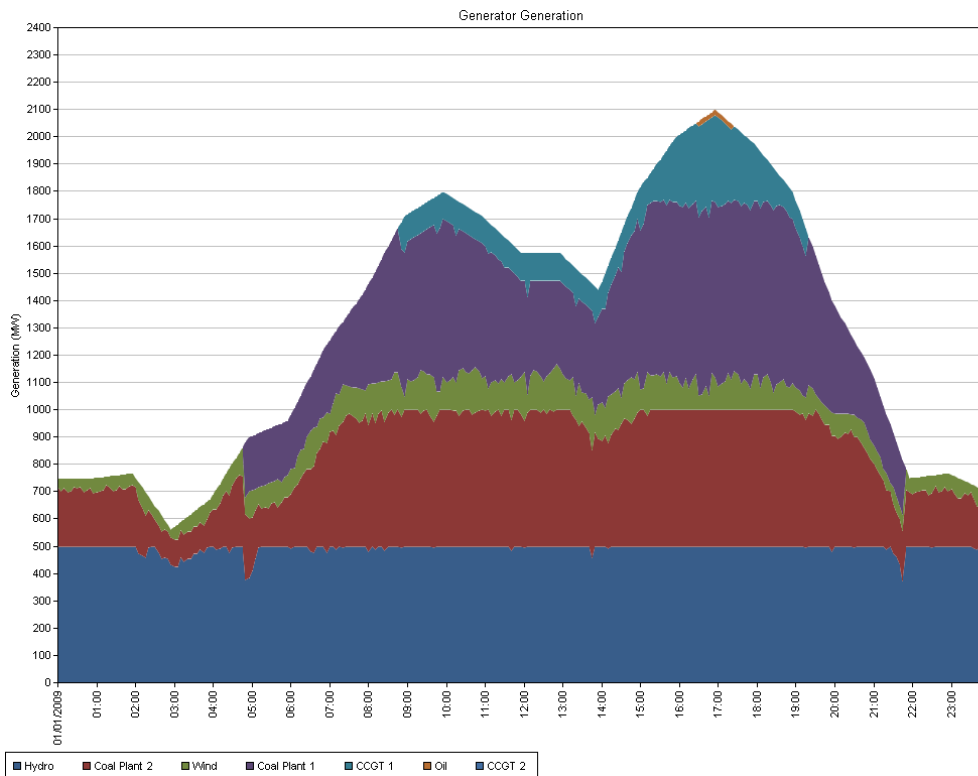


- CCGT now runs all day to cover reserves and energy
- Coal plant 2 also online longer
- Oil unit not required
- Less displacement of hydro generation for ramping



## PLEXOS higher resolution dispatch – 5 Minute Sub-Hourly Simulation

PLEXOS®  
Integrated Energy Model

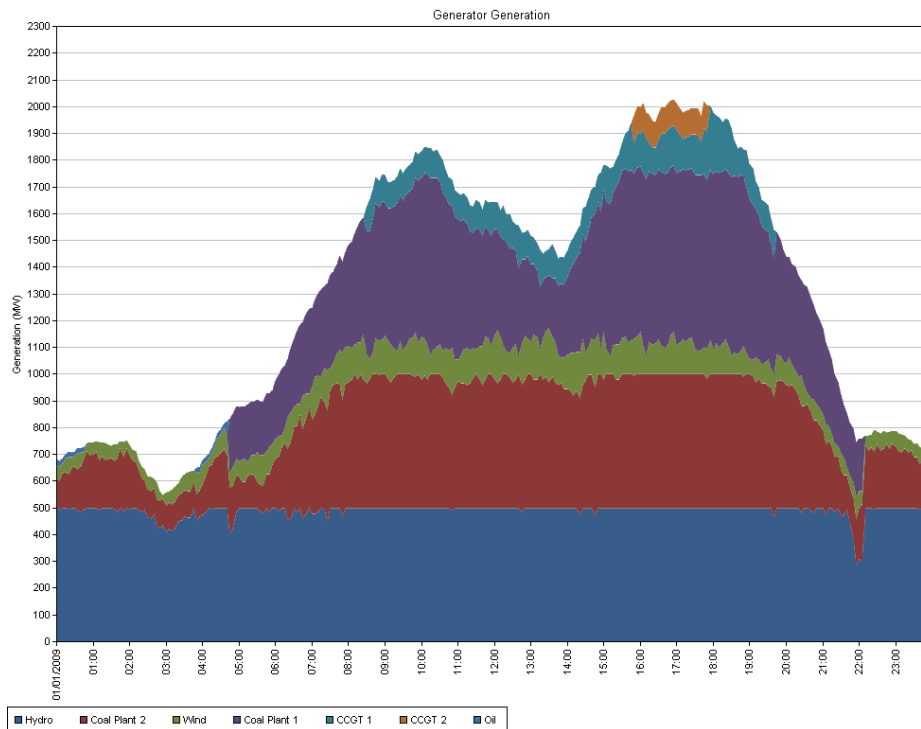


- Oil unit required at peak for increased variability
- Increased displacement of base load to cover for ramping constraints



# Energy/AS Stochastic Co-optimisation

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Integrated Energy Model



- Even though load lower (wind unchanged) more units must be committed to cover the possibility of high load and low wind
- These units must then operate at or above Minimum Stable Level