Locational Price Forecasting and Transmission Rights Evaluation

Transmission Expansion and Reliability
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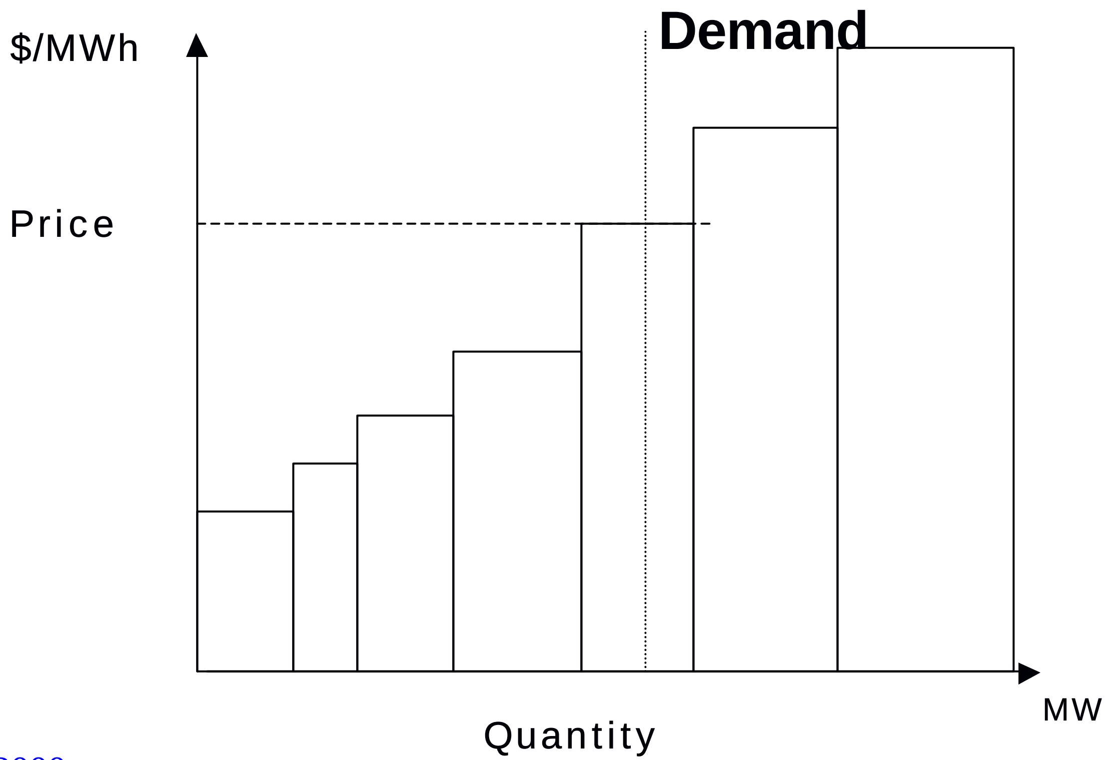
Presentation Outline- Locational Price Forecasting

- Nodal Marginal Pricing - Theory
- Types of Price Forecasting Models
  - Production Cost Models
  - Knowledge-Based Models
  - Stochastic Models
- Important Input Assumptions
- Importance of Sensitivity Analysis

Nodal Marginal Pricing - Theory

- The market clearing price is the marginal cost of the marginal unit in the absence of transmission constraints. In economics terms, the market clearing price is the point of intersection of supply and demand curves.



Nodal Marginal Pricing - Theory

- **In the presence of transmission constraints, the costs of energy production, and thus prices, vary by location.**
- **Nodal pricing applies Spatial Spot Pricing theory on a real time basis to derive a bus by bus Locational Marginal Price (LMP)**
- **Calculations are based on Security Constrained Dispatch model**
- **All transactions on the grid *ARE CHARGED or CREDITED* at the LMP**
- **Generators are paid this price and consumers are charged this price**

LMP Price Calculation Procedures

- **Generators bid their willingness to supply at a node**
- **Consumers bid to purchase at a node**
  - **Reality: Demand is forecasted**
- **In real time the system operator dispatches units so as to minimize cost (including transmission) given bids**
- **LMP calculated for each bus**
- **Pay the generators; Charge the loads**
- **Multiple Clearing times / markets**
  - **Day ahead market to correspond to the scheduling / commitment time frame**
  - **Hour ahead market to correspond to the dispatch time frame**

Nodal Pricing - The Mathematical Model

The model can be mathematically described as follows:

Minimize Total Cost = $\sum_{i \in I} GenCost_i * Gen_i$

Subject to:

(1) $$Gen_i \leq MaxCap_i \qquad \forall i \in I$$

(2) $$\sum_{i \in I} Gen_i = \sum_{a \in A} Load_a + SpinReser_{Pool}$$

(3) $$PowerFlows_l \leq MaxFlows_l \qquad \forall l \in L$$

(4) $$PowerFlows_l \geq MinFlows_l \qquad \forall l \in L$$

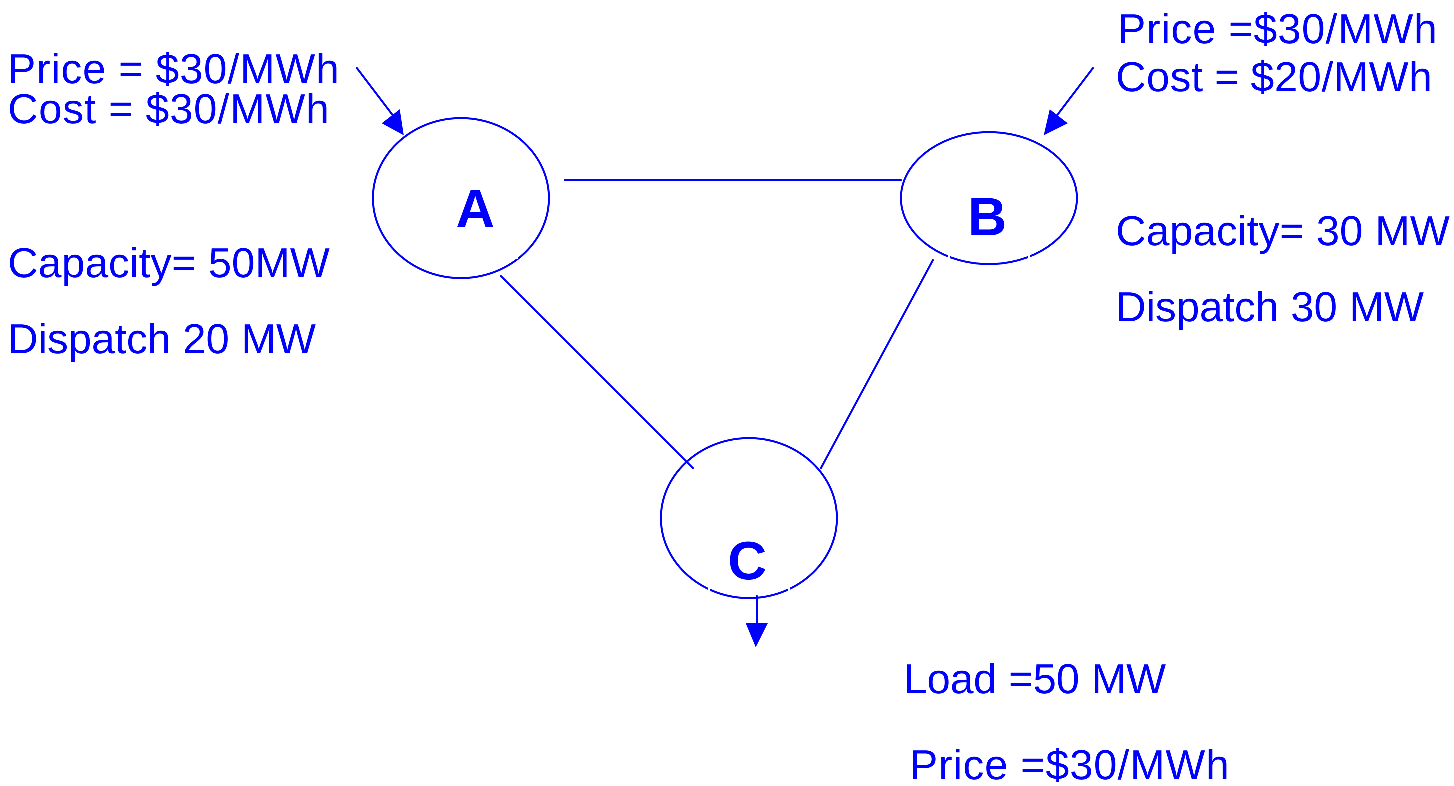
Nodal Marginal Pricing - Theory

Nodal prices are not necessarily capped by the marginal costs of marginal units - they can be higher than the most expensive unit, or negative.

- **Nodal prices can be higher than the marginal cost of the most expensive unit running.**
- **Nodal prices at constrained out areas can be negative.**

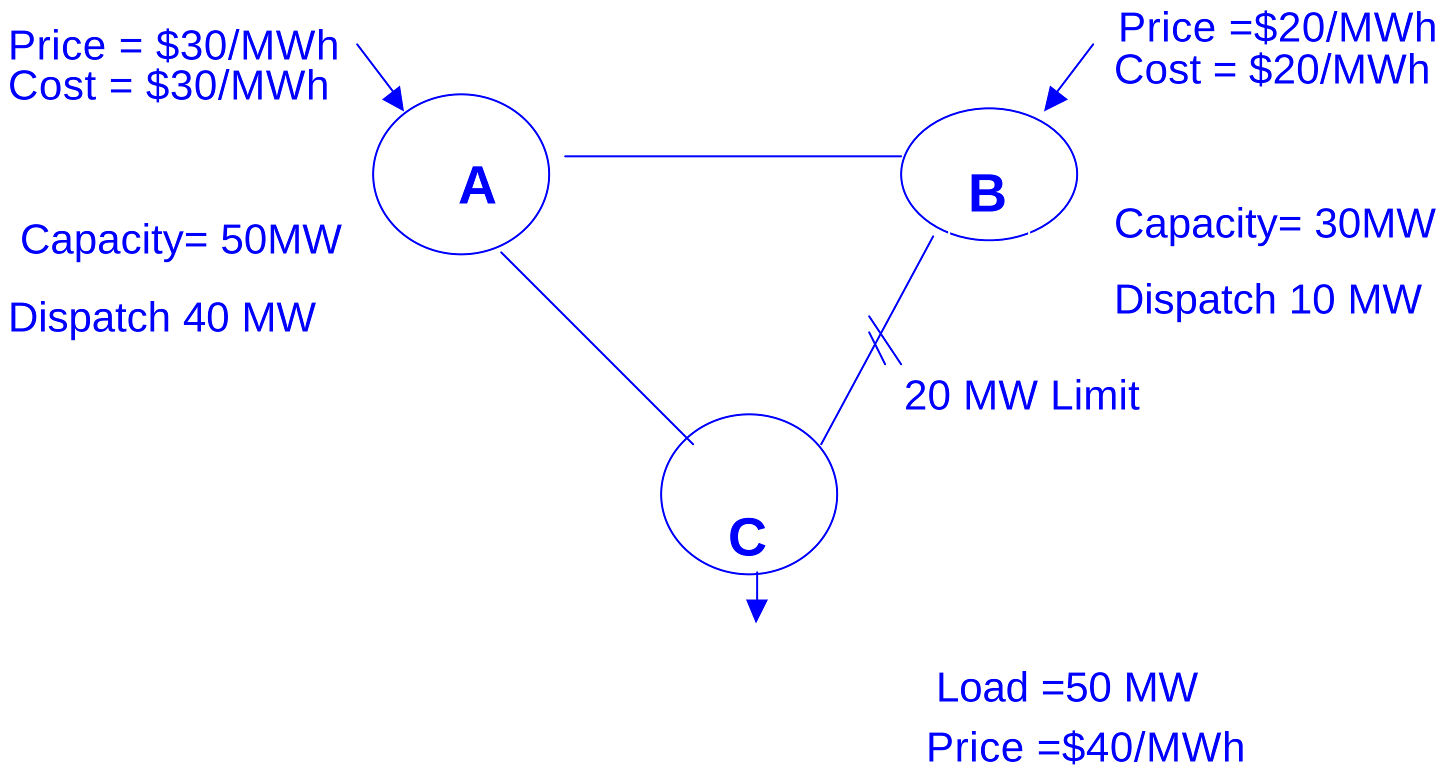
Nodal Marginal Pricing - Theory

Example of nodal prices without constraints.



Nodal Marginal Pricing - Theory

Example of nodal prices *with* constraints. Note that prices can exceed the highest marginal cost unit.



Price Forecasting Models

- **There are three possible approaches to price forecasting:**
  - **Production Cost Models: Build a Market Model with specified assumptions**
    - **Can be complicated**
    - **Results accuracy depends on accuracy of input assumptions**
  - **Stochastic Models: Run a large number of Monte Carlo simulations**
    - **Require large number of simulations**
    - **Require knowledge of the distribution of the input variables**
  - **Knowledge-Based Systems: Try to learn the market by observing prices and relating these to events**
    - **Need to learn all possible events**
    - **Price accuracy depends on the training**

Market Model

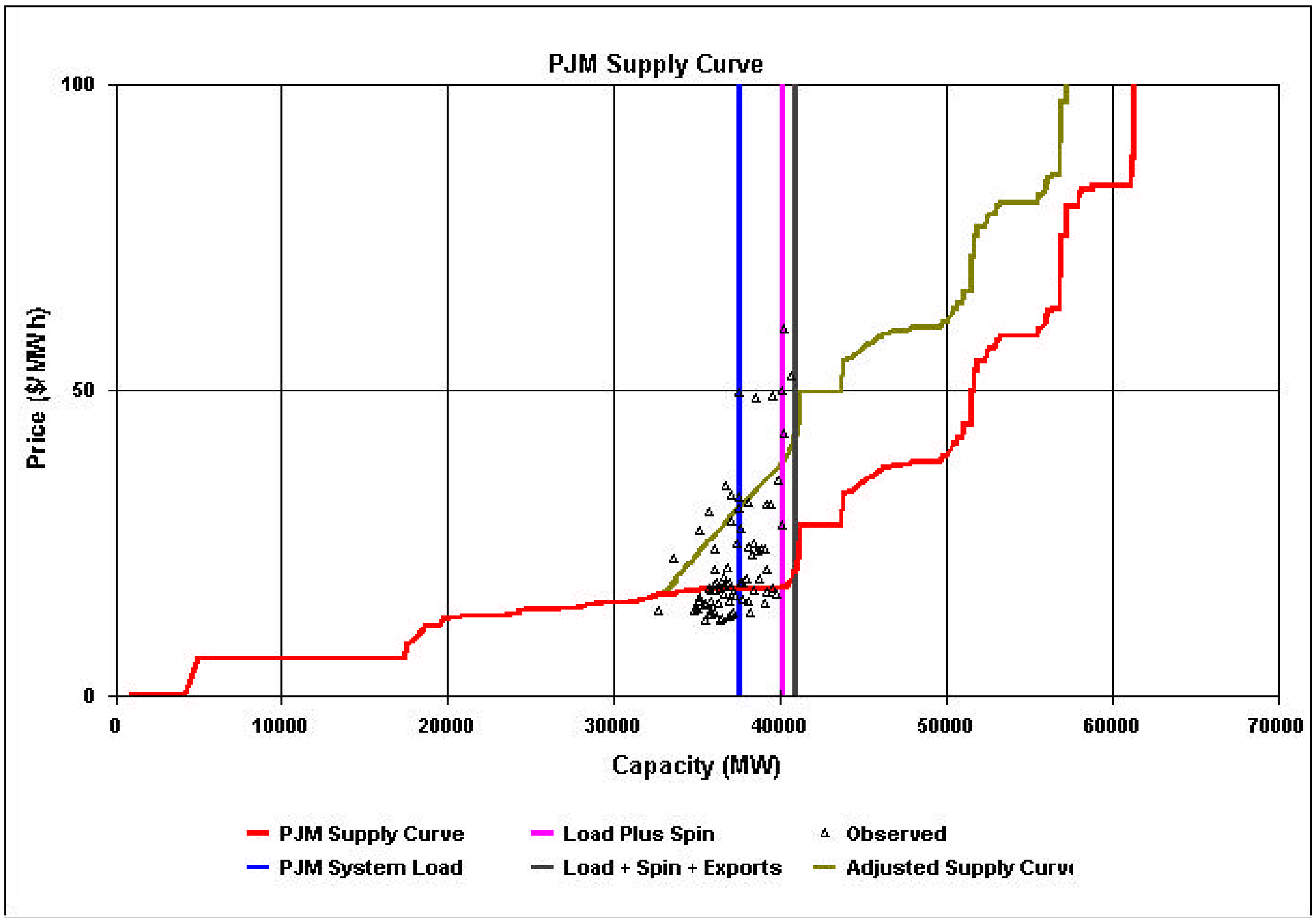
- The market model can be either one of the following:
  - Competitive: Generators bid incremental cost
  - Oligpolostic:
    - Most realistic but difficult to model
    - Many possible equilibria (Nash type equilbira)
  - Monopolistic: Unlikely

Market Equilibria

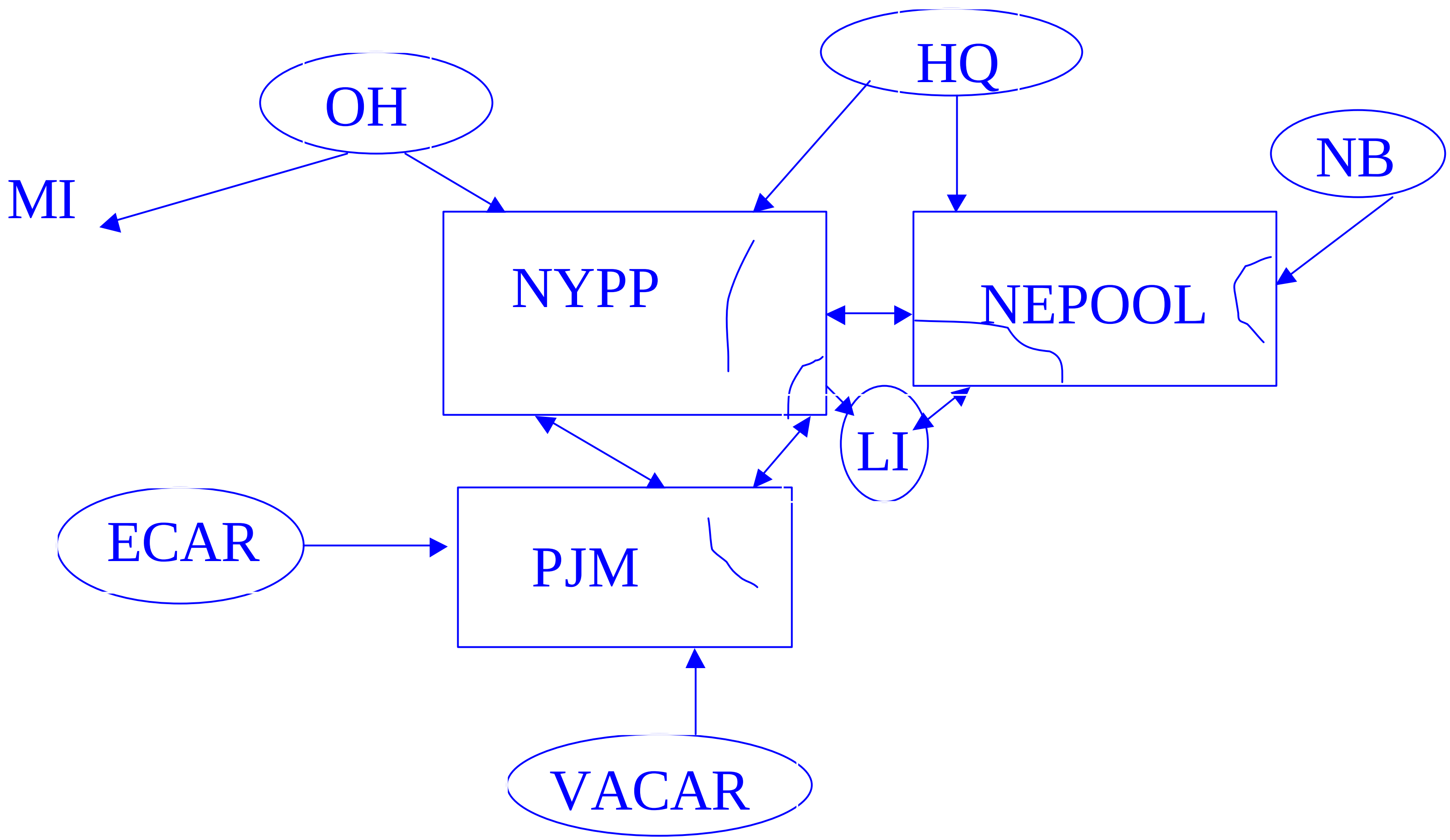
- **Nash: A player maximizing its own payoff given the strategies followed by all opposing players (General equilibrium)**
  - **Cournot: Set of outputs for which each firm maximizes profit given the *outputs* of the remaining firms**
  - **Bertrand: Set of outputs for which each firm maximizes profit given the *prices* of the remaining firms**
  - **Supply Function: Set of outputs for which each firm maximizes profit given the *supply curves* of the remaining firms**

Knowledge-Based Systems

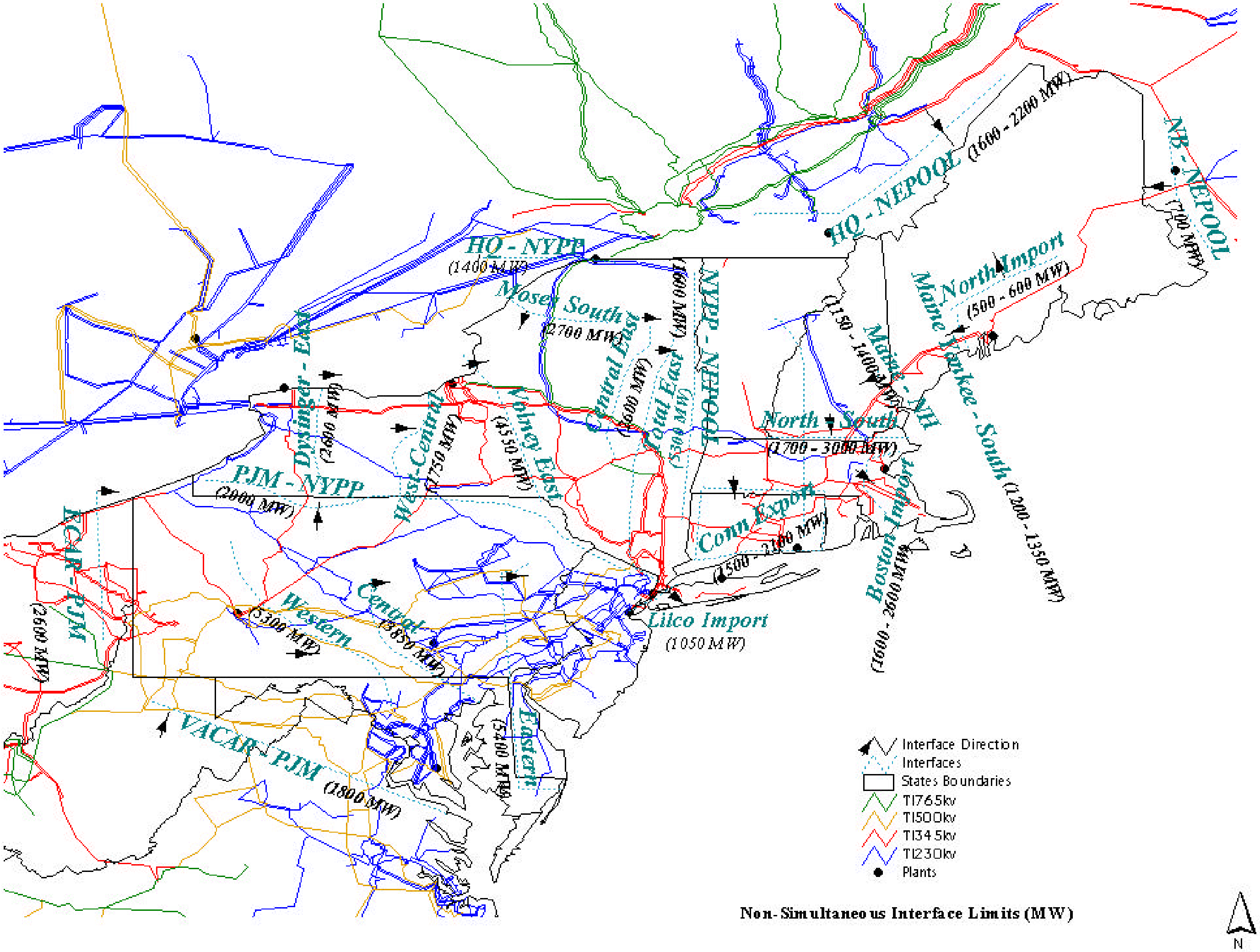
- The model learns the market given observed load,price data points



A Simplified Geographic Model of the Northeast Markets



The Physical Model



Important Input Assumptions

Thermal Characteristics

- **Units Summer and Winter capacities**
- **Units heat rates, fuel types & outages**
- **Units variable operation and maintenance cost by unit type and size**

Hydro Unit Characteristics

- **Hydro and pump storage generation levels**

Fuel Prices

- **Fuel prices for each geographic area**

Transmission System Representation

- **Transmission constraints**

External Supply Curves

- **Imports and exports from outside the Northeast system**

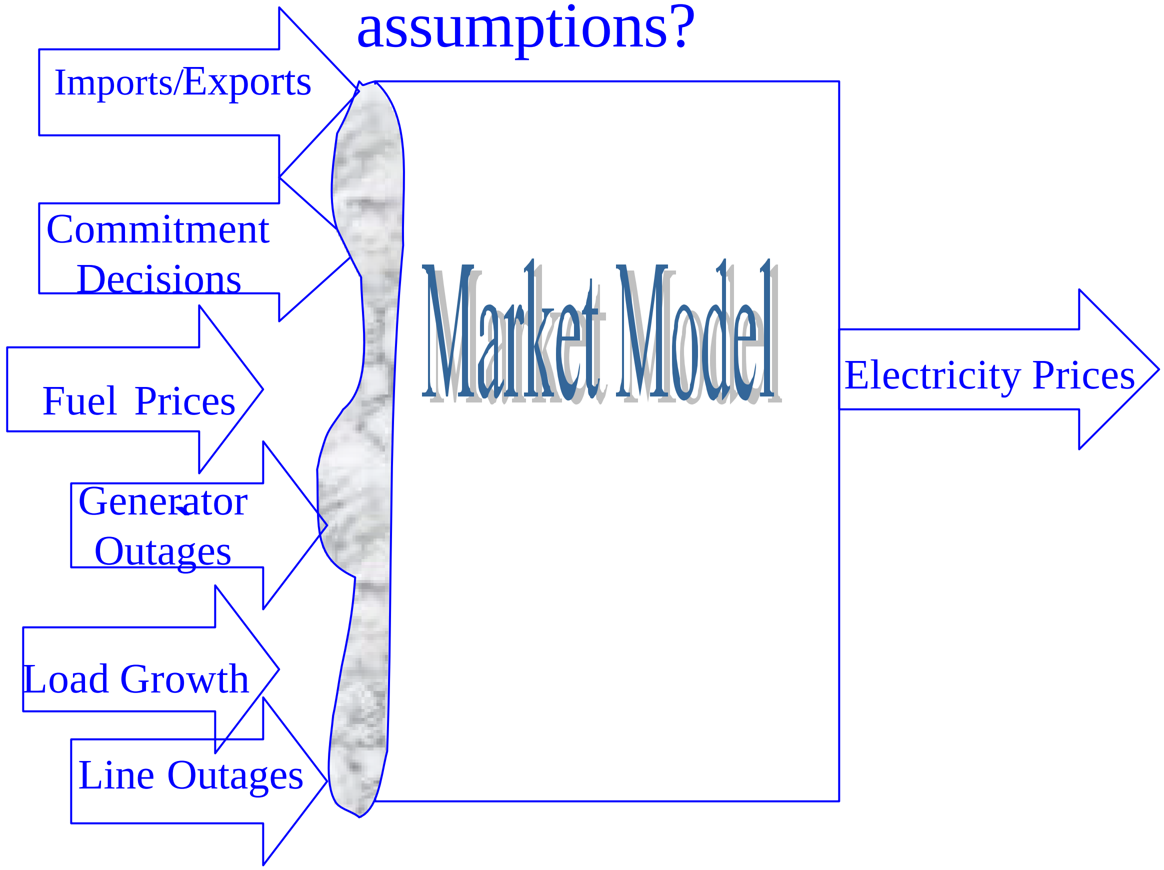
Load Requirements

- **Forecasted peak load and hourly shape, and dispatchable demand**
- **Reserves requirements**

Economic Entry and Retirements

Importance of Sensitivity Analysis

How sensitive are the prices to changes in input assumptions?



Presentation Outline- Transmission Rights Evaluation

- **What are Transmission Property Rights?**
  - **Financial rights (TCCs, FTRs, FCRs, etc..)**
  - **Physical rights**
- **How do we value these rights?**
  - **Obligation type rights**
  - **Option type rights**
- **A look at congestion in NY**
  - **Day-ahead prices**
  - **TCCs auction results (Six month)**
  - **MAPS results for congestion in NY**
- **A look at congestion in the West**
  - **Day-ahead prices**
  - **FTR auction results**

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Alphabet Soup

- **What are TCCs in New York, FTRs in PJM and FCRs in New England?**
- **What do FTRs mean on the east coast and what do they mean on the west coast?**

Transmission Property Rights

- **Financial rights**
  - Guarantees the holder the financial equivalent of using the transmission right, but not the physical certainty.
  - The value is independent of actual power flow, and depends on congestion on the system.
- **Physical rights**
  - The right to inject a certain amount of power at point A and take it out at point B.
  - The holders are guaranteed the scheduling certainty for their rights.
  - Use it or lose it type of rights to prevent hoarding.
- **These different types of rights are equivalent in perfect markets (text book only).**
  - Market power issues
  - Impact on energy market

Valuation of Financial Trans. Property Rights

- **Obligation type rights**
  - **The value of the right is equal to the LMP at receiving point minus the LMP at the sending point, times the quantity of the right.**
  - **The holders are responsible for negative payments**
  - **Example: NY ISO TCCs and PJM FTRs**
- **Option type rights**
  - **Same as obligation type rights except that the holders are NOT responsible for negative payments**
  - **Example: CA ISO FTRs**

The locational price could be nodal (east coast) or zonal (west coast)

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Valuation of Physical Trans. Property Rights

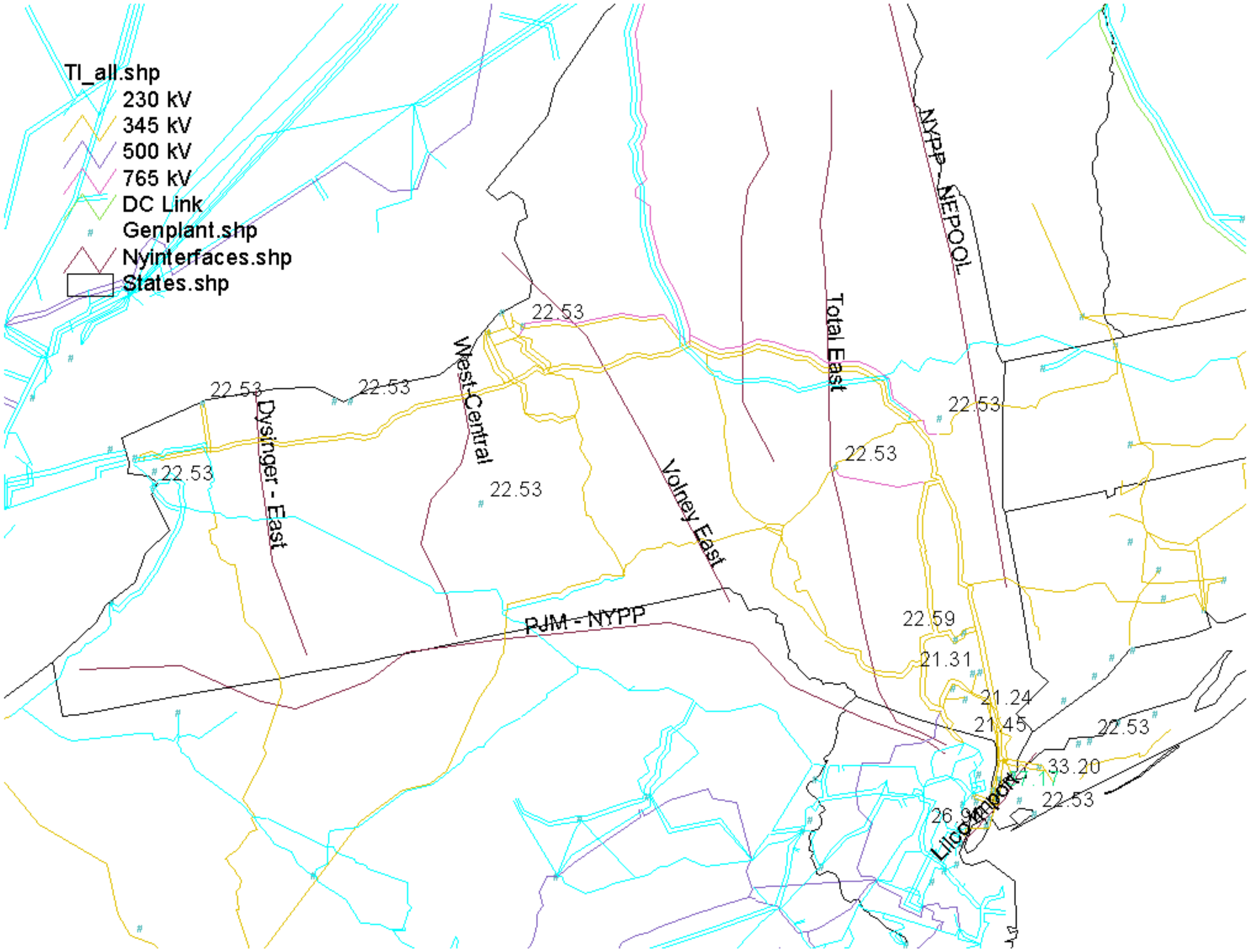
- The value of physical transmission property right is the same as an option type financial right, i.e., the difference between the receiving and sending points when that difference is positive only.
- The physical rights allow holders to schedule energy to flow when the energy price at the receiving end is higher than the price at the sending end.

New York Monthly Average Day-Ahead Prices [$/MWh, No Losses]

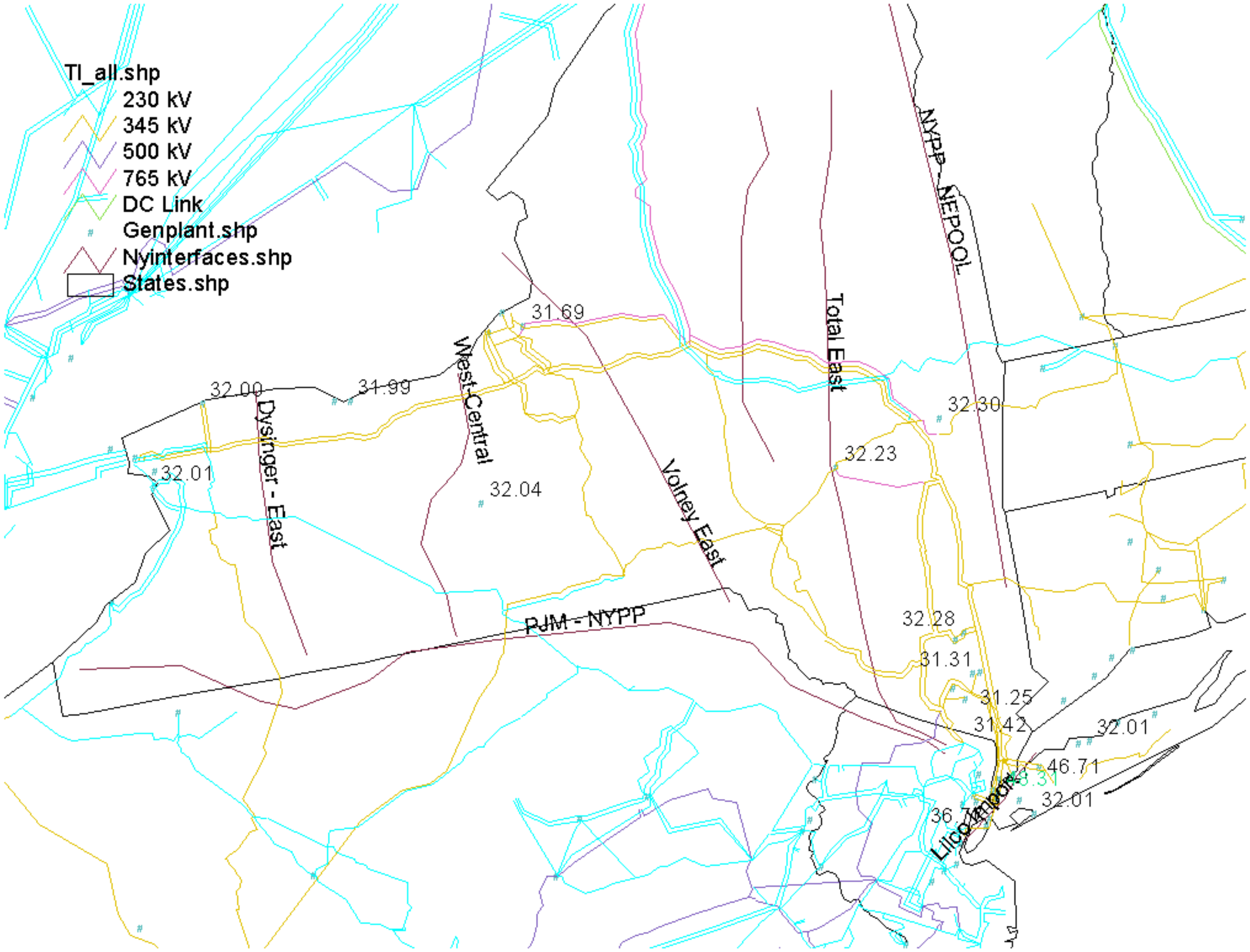
As expected, New York city and Long Island have the highest energy prices followed by the eastern part of NY.

Plant	Dec	Jan	Feb
C. R. Huntley	22.53	32.01	30.76
Allen E. Kintigh	22.53	32.00	30.73
Ginna Nuclear	22.53	31.99	30.70
Milliken Station	22.53	32.04	30.80
J. A. Fitzpatrick	22.53	31.69	30.58
Gilboa	22.53	32.23	32.19
Albany	22.53	32.30	32.72
Danskammer Point	22.59	32.28	32.40
Indian Point 2	21.24	31.25	30.85
Indian Point 3	21.31	31.31	31.38
Bowline Point	21.45	31.42	30.76
East River	26.90	36.77	36.40
Astoria	37.17	48.31	36.20
E. F. Barrett	22.53	32.01	30.49
Holtsville	22.53	32.01	30.49
Glenwood	33.20	46.71	49.87

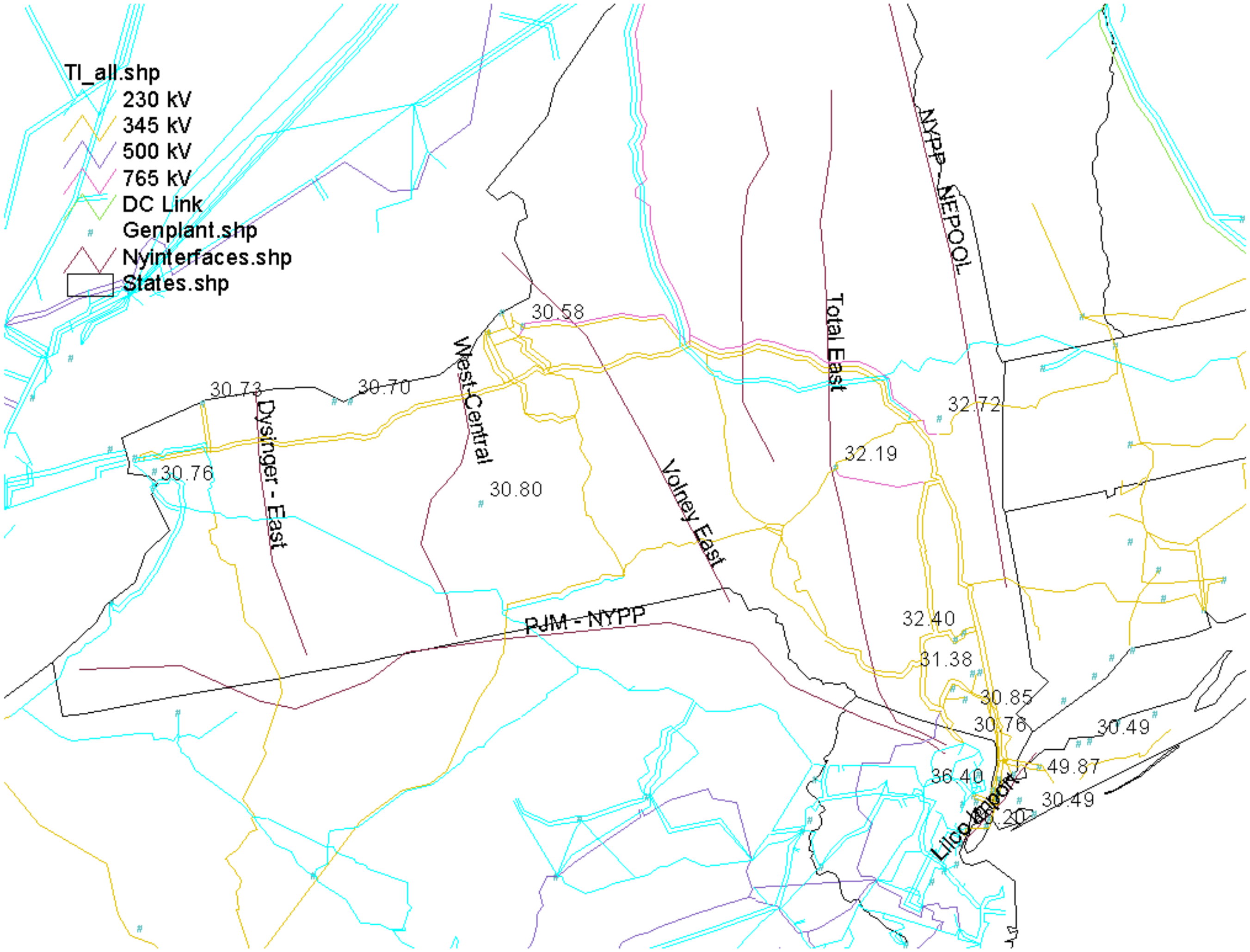
December Prices [$/MWh]



January Prices [$/MWh]



February Prices [$/MWh]



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New York TCC Six-Month Auction Results

The market reacts to actual prices, and the value of TCCs follow the pattern of congestion. However, the absolute value is higher than historic data. It is either that the market expects a bad summer, or places high premium on hedging congestion risks.

Plant	Round 1	Round 2	Round 3	Round 4	Average ($/TCC)	Average ($/MWh)
C. R. Huntley	3,187	2,583	8,332	1,876	3,994	0.90
Allen E. Kintigh	2,573	2,267	6,491	1,606	3,234	0.73
Ginna Nuclear	2,666	2,015	5,675	1,478	2,959	0.67
Milliken Station	5,355	3,359	7,989	2,568	4,818	1.09
J. A. Fitzpatrick	1,570	1,231	2,959	915	1,669	0.38
Gilboa	9,948	21,774	24,995	16,662	18,345	4.15
Albany	17,664	28,149	33,951	21,100	25,216	5.71
Danskammer Point	29,814	26,757	34,001	19,099	27,418	6.21
Indian Point 2	33,294	26,043	33,645	18,046	27,757	6.29
Indian Point 3	33,831	26,096	33,771	18,072	27,943	6.33
Bowline Point	32,614	25,952	33,580	18,033	27,545	6.24
East River	51,111	42,852	50,318	34,197	44,619	10.10
Astoria	58,325	64,891	74,000	50,224	61,860	14.01
E. F. Barrett	31,828	28,697	33,735	20,624	28,721	6.50
Holtsville	32,225	29,045	34,146	20,879	29,074	6.58
Glenwood	31,510	28,378	33,380	20,388	28,414	6.43

TCA MAPS Analysis Results

MAPS does a good job in predicting the pattern of congestion, but not market participants appetite for risk and gaming. These results assume short-run marginal cost bidding (Typically, our analysis is supplemented with a strategic bidding model.)

Plant	May-Oct 2000 Avg ($/MWh)
C. R. Huntley	26.24
Allen E. Kintigh	26.67
Ginna Nuclear	26.98
Milliken Station	27.32
J. A. Fitzpatrick	27.45
Gilboa	28.85
Albany	29.10
Danskammer Point	29.23
Indian Point 2	29.48
Indian Point 3	29.45
Bowline Point	29.48
East River	29.52
Astoria	34.70
E. F. Barrett	37.93
Holtsville	38.15
Glenwood	37.91

CA ISO Monthly Day Ahead Congestion Prices

The CA ISO uses a simplified representation of the transmission system, with 20 scheduling points and three active zones in CA (SP 15, NP15 and ZP26).

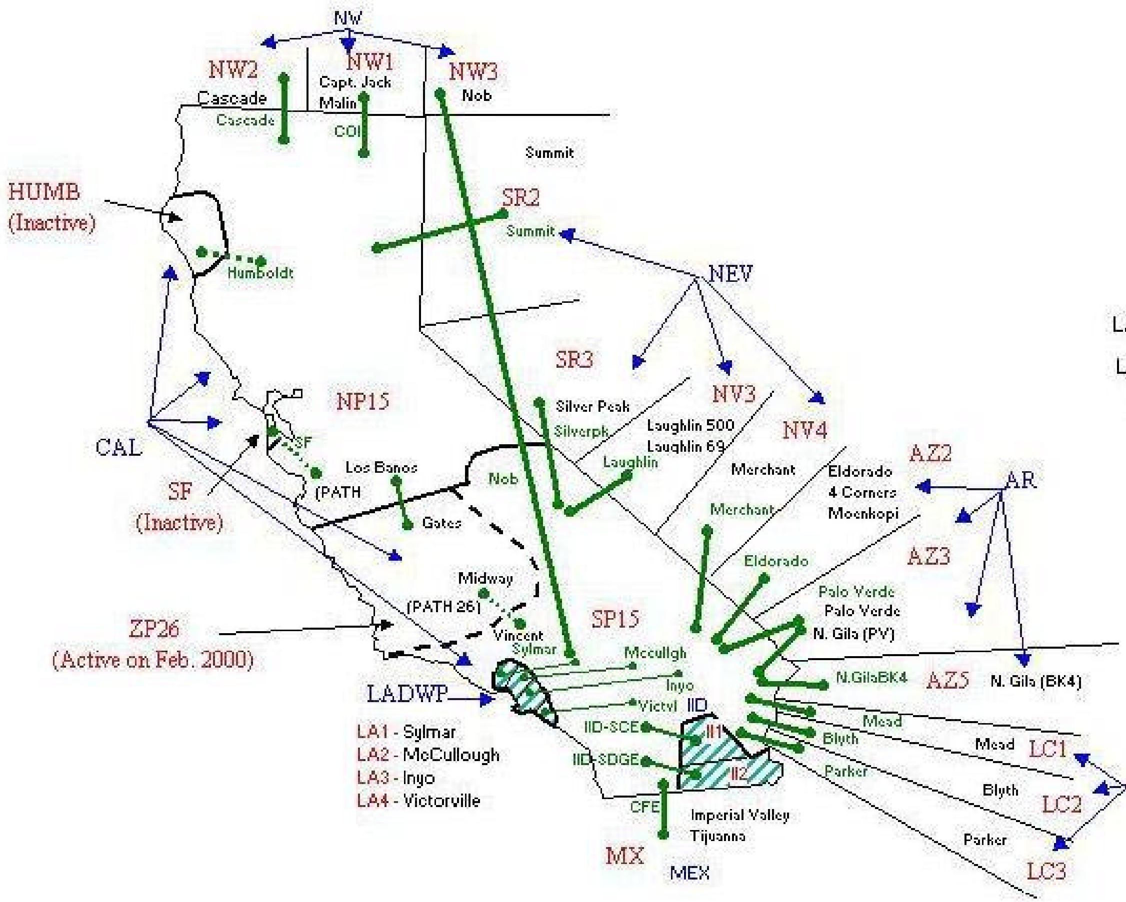
Auction	Zone		ISO DA Prices ($/MWh)		
Name	From	To	Feb-00	Mar-00	Apr-00
CFE _BG	MX	SP15	-	-	-
CFE _BG	SP15	MX	-	-	-
COI _BG	NP15	NW1	-	-	-
COI _BG	NW1	NP15	0.67	0.51	0.48
ELDORADO _BG	AZ2	SP15	1.52	0.03	0.09
ELDORADO _BG	SP15	AZ2	-	-	-
IID-SCE _BG	II1	SP15	-	-	-
MEAD _BG	LC1	SP15	0.10	0.29	0.79
MEAD _BG	SP15	LC1	-	-	-
NOB _BG	NW3	SP15	0.03	0.15	1.27
NOB _BG	SP15	NW3	-	-	-
PALOVRDE _BG	AZ3	SP15	0.74	2.72	-
PALOVRDE _BG	SP15	AZ3	-	-	-
PATH26 _BG	SP15	ZP26	0.00	0.00	0.00
PATH26 _BG	ZP26	SP15	0.29	1.19	1.48
SILVERPK _BG	SP15	SR3	-	-	-
SILVERPK _BG	SR3	SP15	-	-	0.05
VICTVL _BG	LA4	SP15	-	-	-
VICTVL _BG	SP15	LA4	-	-	-

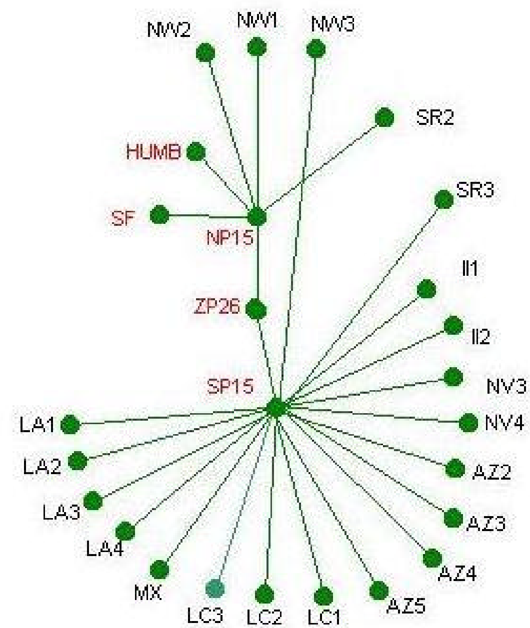
CA FTR Auction Results (Feb 2000 - Mar 2001)

It seems that the market is expecting significant congestion this summer especially across the COI path. The market expected congestion pattern is inconsistent with realized congestion so far (Path26 BG). It is more difficult to forecast congestion patterns in the west mainly because of hydro and nuclear units `availability.

Auction	Zone		Clearing Price	Price
Name	From	To	($/MW, 14 mth)	$/MWh
CFE _BG	MX	SP15	165	0.02
CFE _BG	SP15	MX	275	0.03
COI _BG	NP15	NW1	1,845	0.18
COI _BG	NW1	NP15	31,500	3.09
ELDORADO _BG	AZ2	SP15	9,975	0.98
ELDORADO _BG	SP15	AZ2	375	0.04
IID-SCE _BG	II1	SP15	425	0.04
MEAD _BG	LC1	SP15	865	0.08
MEAD _BG	SP15	LC1	1,485	0.15
NOB _BG	NW3	SP15	7,500	0.74
NOB _BG	SP15	NW3	555	0.05
PALOVRDE _BG	AZ3	SP15	5,800	0.57
PALOVRDE _BG	SP15	AZ3	575	0.06
PATH26 _BG	SP15	ZP26	620	0.06
PATH26 _BG	ZP26	SP15	3,600	0.35
SILVERPK _BG	SP15	SR3	550	0.05
SILVERPK _BG	SR3	SP15	8,985	0.88
VICTVL _BG	LA4	SP15	100	0.01
VICTVL _BG	SP15	LA4	170	0.02

CA ISO Zonal System





Conclusions

- Forecasting models are not crystal balls and should not be used as such.
- They cannot account for market participants risk premiums or for gaming in the energy market.
- Models are good tools to forecast congestion patterns and predict congestion on the system.
- They are useful to develop understanding of transmission system conditions and sensitivities to various random parameters.