Congestion Pricing Mechanisms From Nodal to Zonal and Beyond

Chicago, Illinois

June 21, 2000

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Agenda

MORNING SESSION - Theory and Concept

- Overview of Spot Pricing
- Objectives of Congesting Pricing Mechanisms (CPM)
- Nodal Marginal Cost Pricing
- Transmission Property Rights
- Zonal Pricing
- Flow-based Pricing

AFTERNOON SESSION - A Touch of Reality

- Nodal v. Zonal Comparison
- Nodal Pricing in Reality - PJM, NYPP
- Zonal Pricing in Reality - California
- Alternatives to Nodal and Zonal
- Solutions for the Midwest

A Little Bit on TCA

- **Engineering and Management Consulting firm specializing in Energy and Manufacturing Systems**
  - **Primary energy focus is electric and gas generation, transmission distribution and consumption**
- **TCA Provide Services in:**
  - **Regulatory Policy at Federal and State Levels and International**
  - **Project / Investment Evaluation**
  - **Software Development (both custom and marketable)**
  - **Market Price Forecasting**
  - **Commercial and Industrial Energy Efficiency**
- **25 Employees in Cambridge MA and Northern California**

T C A

What is Spot Pricing?

Prof Fred C. Schweppe of MIT, with M. Caramanis, R. Tabors and R. Bohn developed the theory of spot pricing, which was published in 1989 in 'Spot Pricing of Electricity.'

- **If we believe microeconomics, then the price customer should see is the marginal cost of production of electricity**
- **Called the Spot Price, Real Time Price (RTP) etc.**
- **For any point in time (and space) the price is uniquely a function of:**
  - **Marginal Cost of generation**
  - **Marginal Cost of losses**
  - **Marginal Cost of transmission**
  - **Quality of Supply (opportunity cost of unserved energy)**

Spatial Spot Price Calculation

- **Based on one of several tools**
  - **Optimal Power Flow (OPF)**
  - **Security Constrained Dispatch (NYPP and PJM)**
  - **Other …**
- **Requires the Shadow Price for energy at any bus in the system, i.e. the cost / value of an additional kWh supplied or demanded at any bus in the system**

- **Within a network, power flows are based on Kirchhoff's laws**
- **OPF answers the question "given the physical structure of the transmission system including all limits on flows *AND* the marginal cost of generation of every unit on the system *AND* a pattern of demand, what is the least costly way to dispatch the resources so as to meet that demand?"**

The Practical Answer -

- **Given that I now know the SRMC at each bus, the *VALUE* of transmission between any two buses is uniquely defined as the difference in the Spatial Spot Prices between the bus of injection and the bus of withdrawal**
- **NOTE that this value can be either positive or negative and that it can be greater than any single Generator's cost (system lambda).**

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Objectives of Congestion Pricing Mechanisms (CPM)

- **Under the Order No. 888 regime, congestion is not priced, but socialized ex-post on a cost-basis to firm users of the system.**
- **Congestion is managed through Transmission Loading Relief (TLR) procedures, which curtails based on service priority (rule based system instead of a market based congestion management system)**
- **This approach fails to:**
  - **PROVIDE EFFICIENT PRICE SIGNALS FOR FUTURE INVESTMENT**
  - **ALLOW USERS TO BID THEIR WILLINGNESS TO PAY FOR SCARCE RESOURCES**
  - **ALLOCATE CONGESTION COSTS BY CAUSATION.**

Objectives of CPM

- Economically efficient (locational) market for
  - Energy
  - Capacity -- Generation and Transmission
- Economically efficient signals for
  - Location of new generation
  - Investment in Transmission
- Implementable solution with acceptable transaction costs
  - Actual dollar costs for running the system
  - Level of liquidity in the market
    - Market entry barriers -- information

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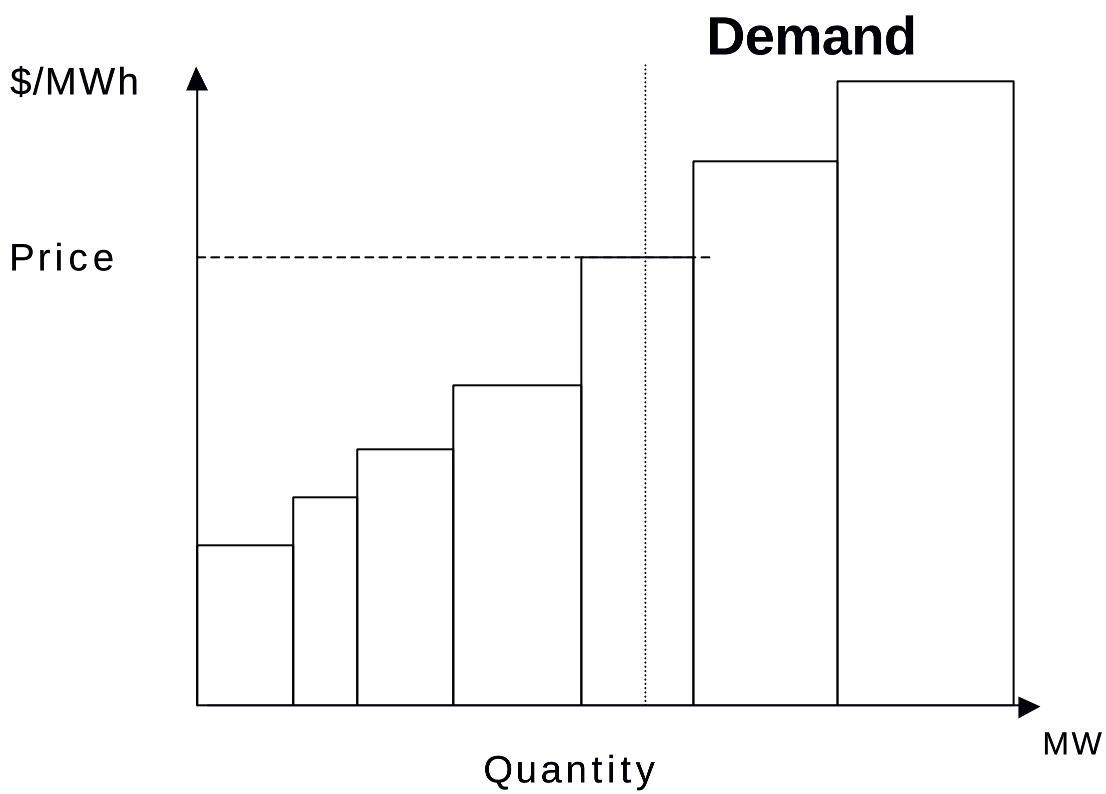
Nodal Marginal Pricing - Theory

- **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.**



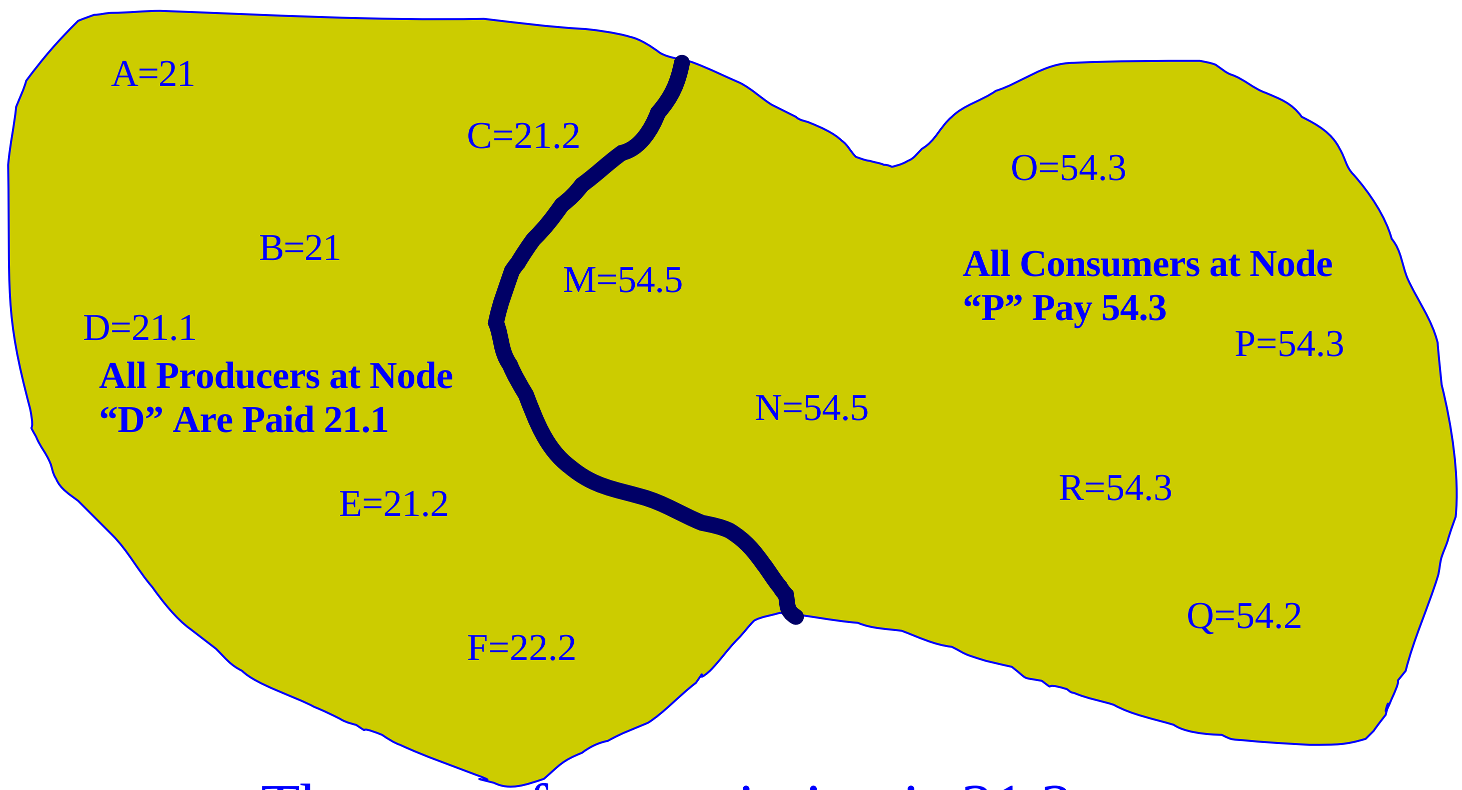
Nodal Marginal Pricing - Theory

- **In the presence of transmission constraints, the cost of producing energy differs 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 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
- Theoretically, 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
- "After the fact" (ex-post), calculate the LMP for each bus
- Pay the generators; Charge the loads
- Multiple Clearing times / markets
  - After the fact charge for all energy transacted that has *not* been "locked in" day or hour ahead
  - Day ahead market to correspond to the scheduling / commitment time frame
  - Hour ahead market to correspond to the dispatch time frame

LMP Calculations - Illustration



The cost of transmission is 31.2
for a transaction from D to P

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) $Gen_i \leq MaxCap_i \quad \forall i \in I$

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

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

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

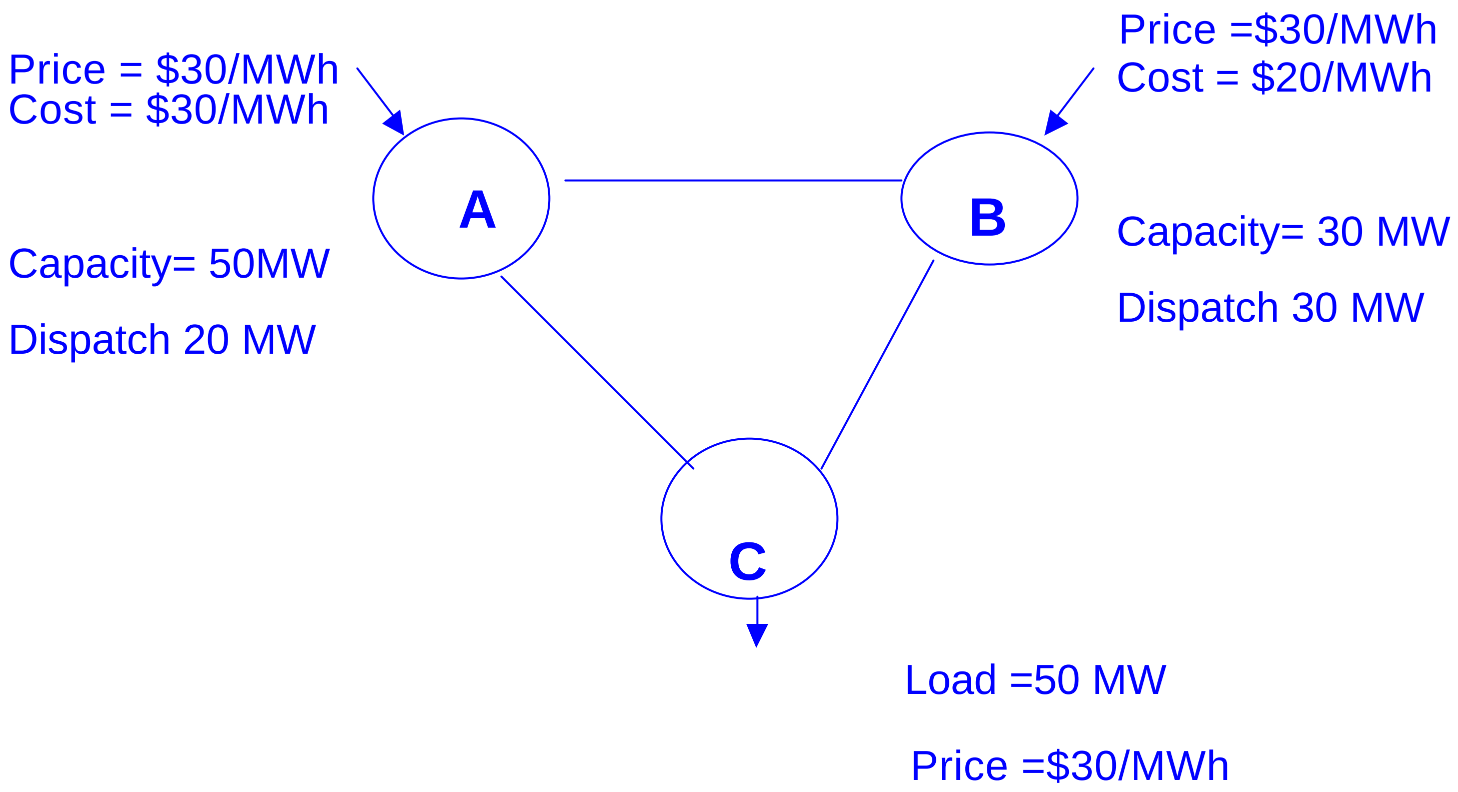
Nodal Marginal Pricing - Theory

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.**

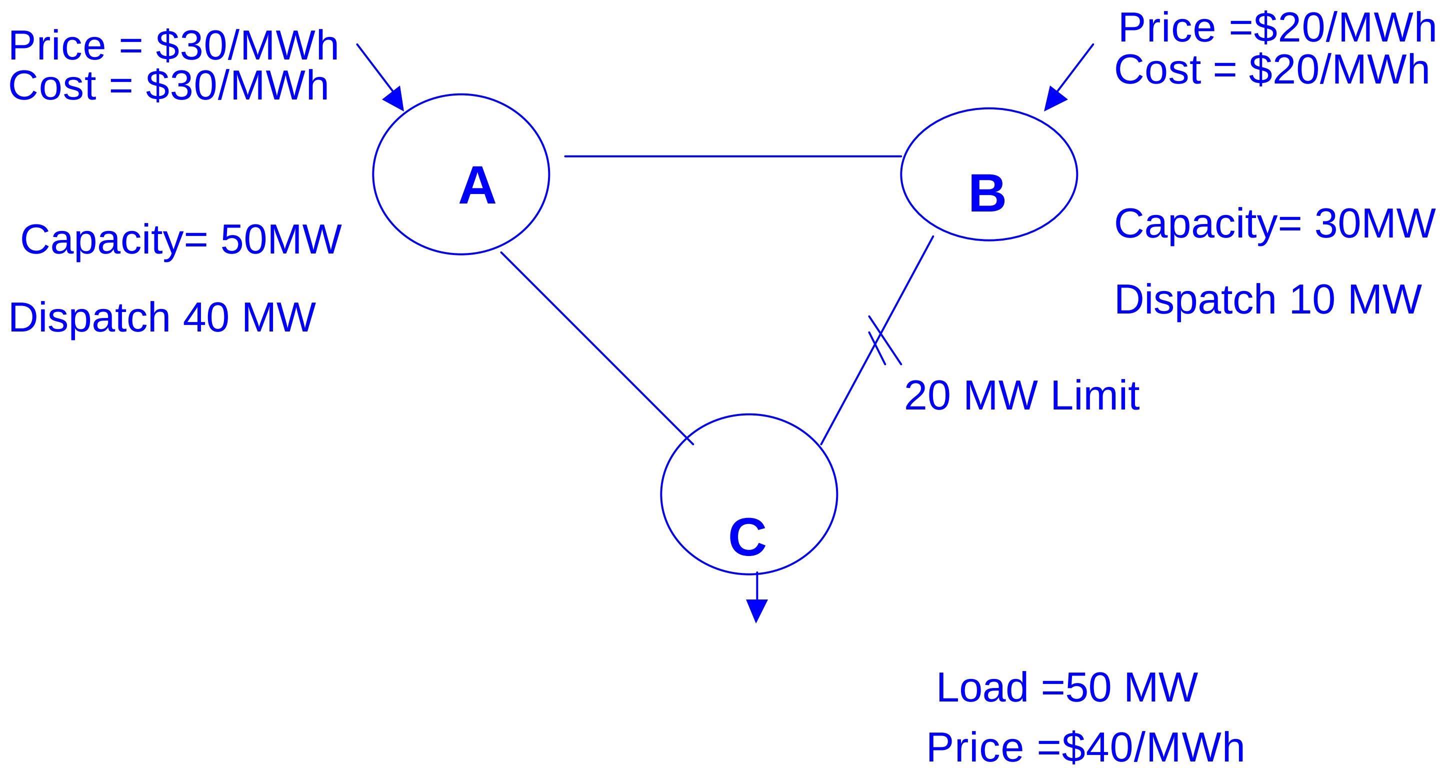
Nodal Marginal Pricing - Theory

Example of nodal prices without constraints.

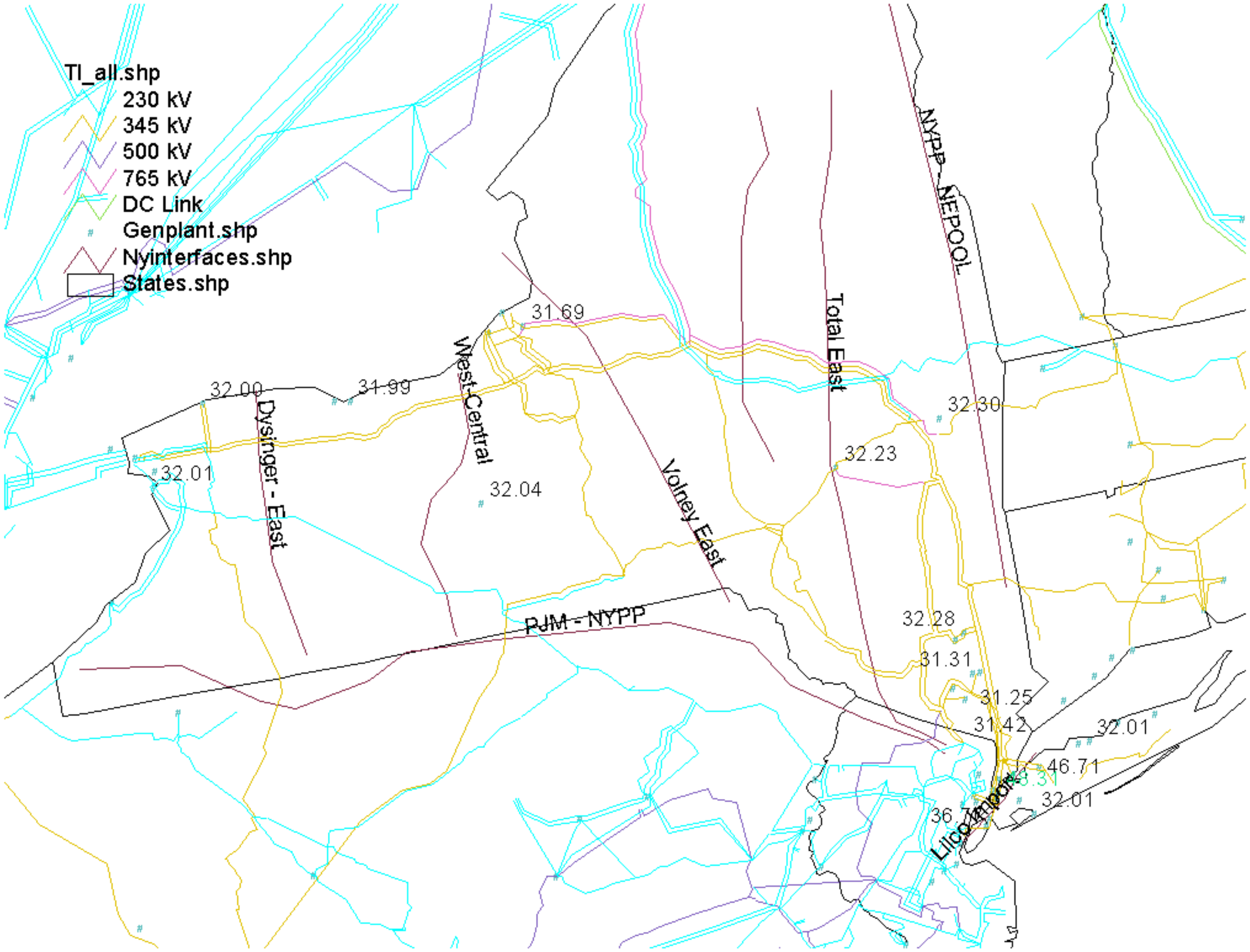


Nodal Marginal Pricing - Theory

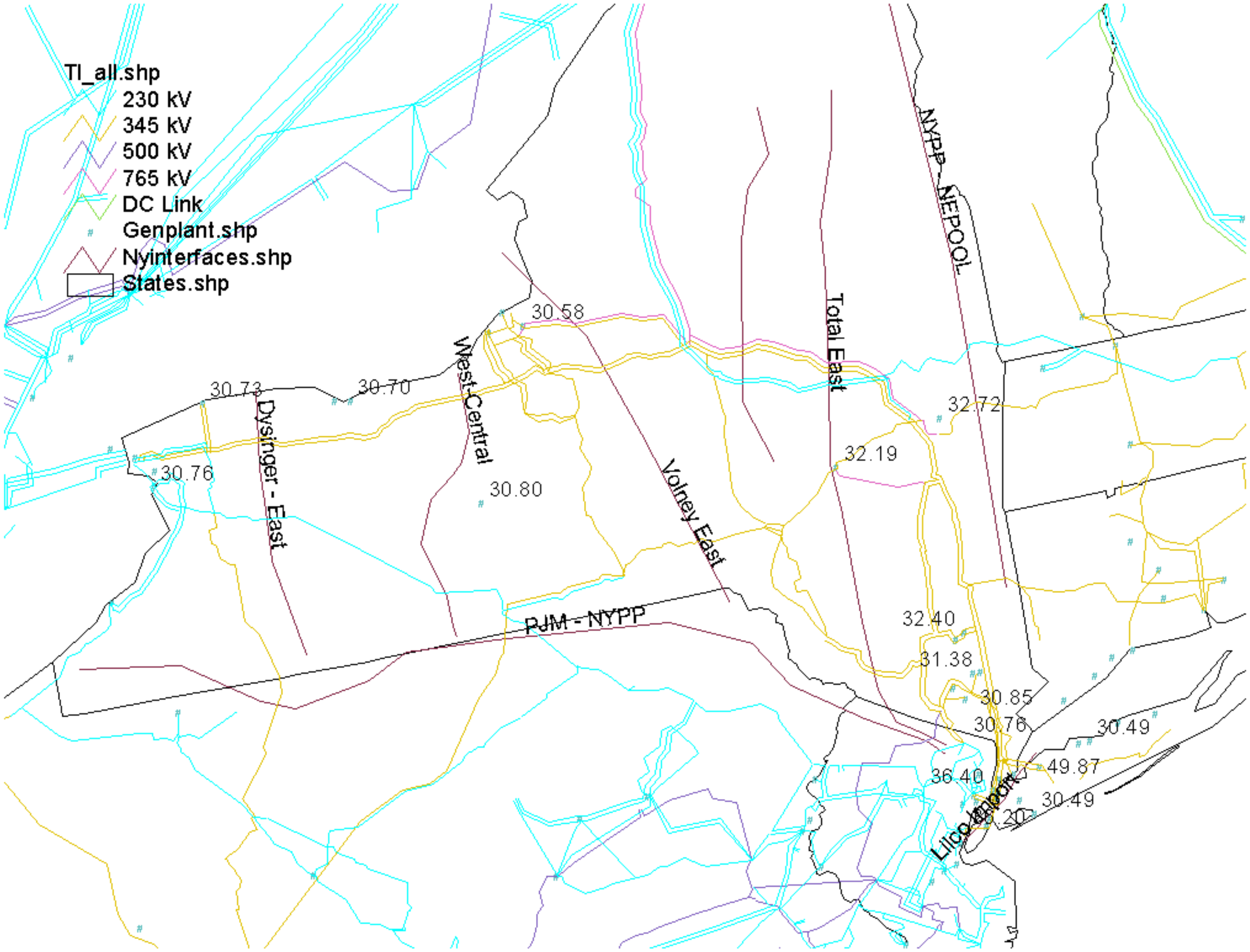
Example of nodal prices *with* constraints. Note that prices can exceed the highest marginal cost unit.



LBMP Examples: NY ISO January Prices [$/MWh]
No Losses



LBMP Examples: NY ISO February Prices [$/MWh] No Losses



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Transmission Property Rights

- Financial rights
  - Guarantees the holder the financial equivalent of using the transmission right, but not the physical certainty (could be easily added).
  - 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).

Transmission Property Rights

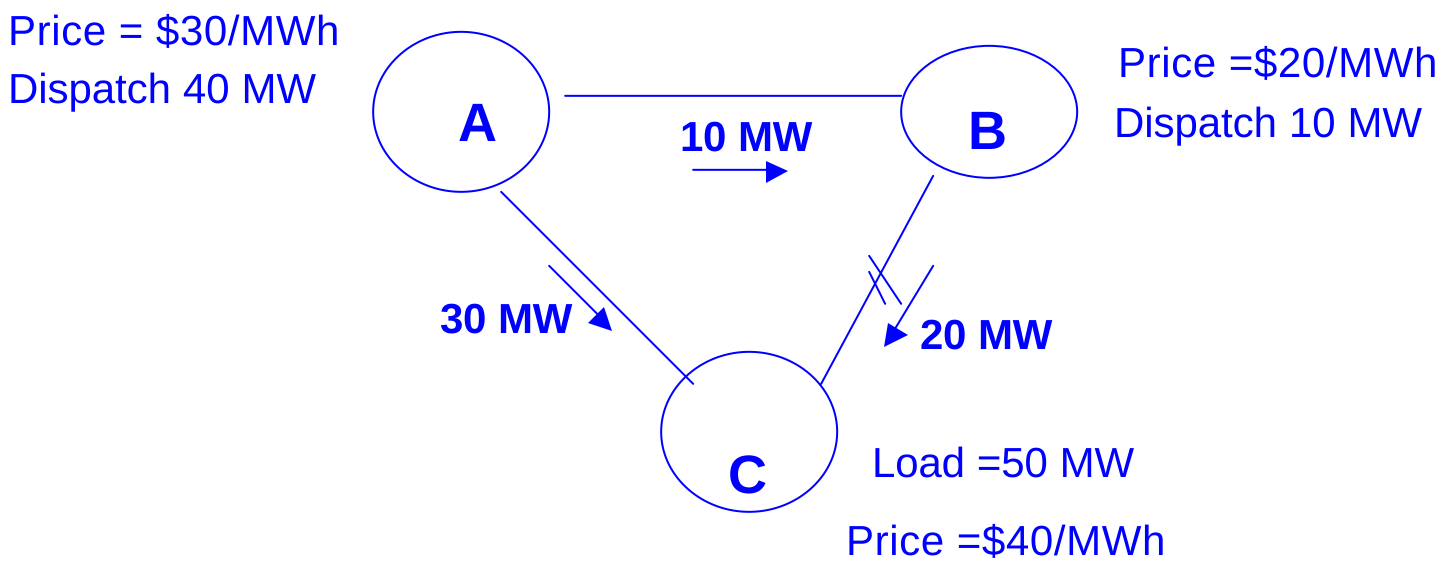
- **The difference is in the final settlement process and impact on the value of the transmission rights**
- **Physical rights are difficult to implement in a nodal-pricing scheme**
- **Zonal pricing schemes may be designed with physical (MW ISA) or financial (CA ISO) rights.**

Financial Rights

- A Financial Hedge against the ex post calculated LMP
- Purchased in advance / Auctioned in advance / Allocated in advance
- Theoretically a zero sum transaction on the day of delivery
- Because you flow first and calculate second the overall system will minimize the total cost of all transactions that are scheduled

Financial Rights - Example

Congestion "rent" goes to the holder of transmission rights on each of the interfaces.



Holder of Right (A- B) *pays* ($20-$30)* 10 MW = - $100

Holder of Right (A- C) *gets* ($40-$30)* 30 MW = $300

Holder of Right (B- C) *gets* ($40-$20)* 20 MW = $400

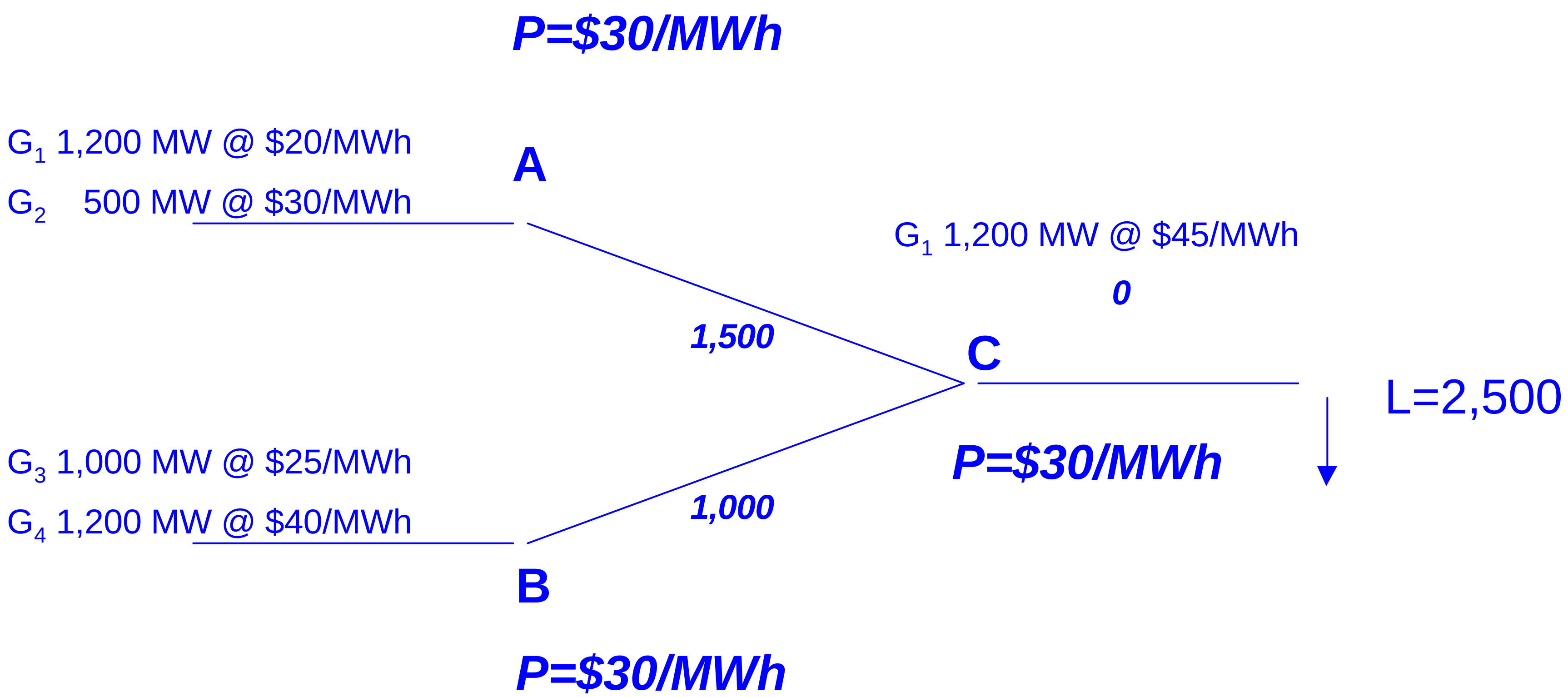
Congestion "rent" = $600

Generators payments $30/MWh *40 MWh+$20/MWh*10MWh = $1400

Load pays $40/MWh*50 MWh = $2000

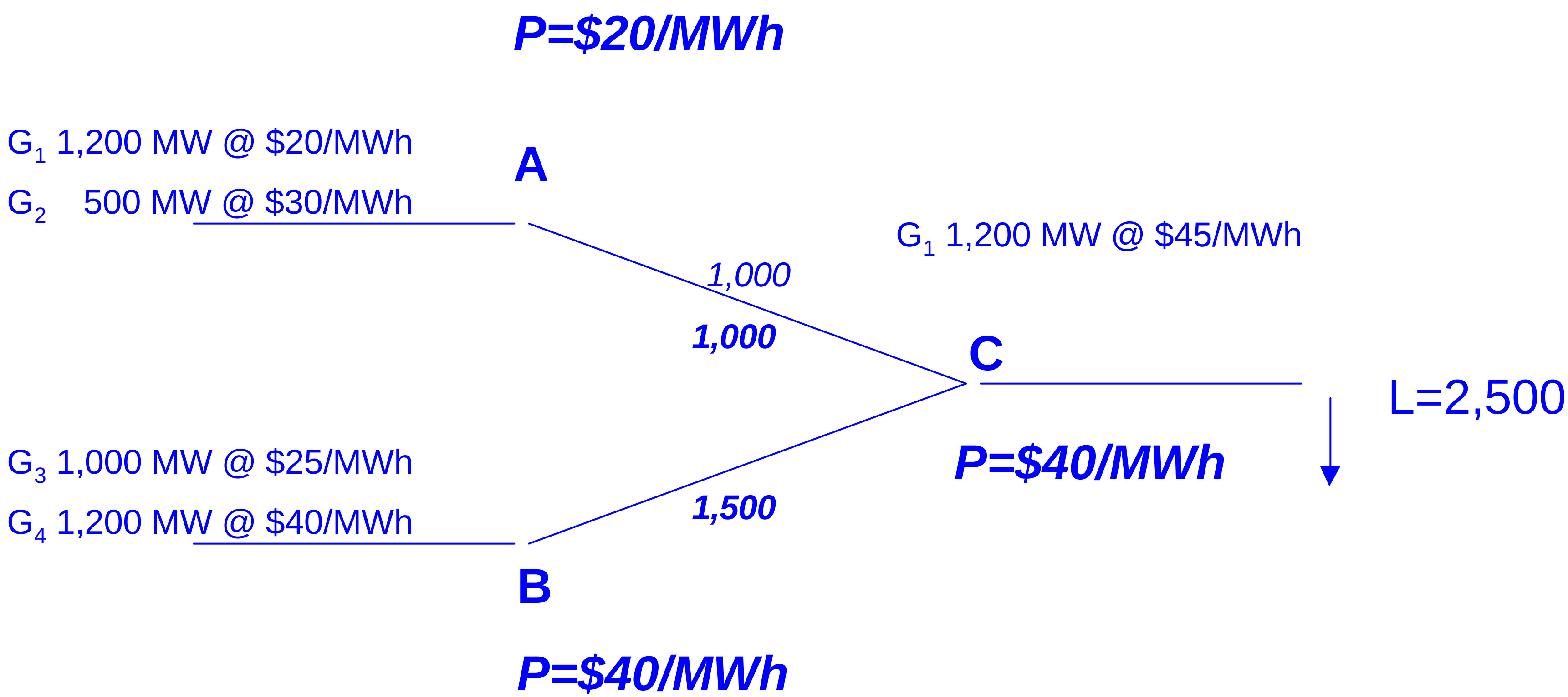
Physical vs. Financial - Example

Unconstrained



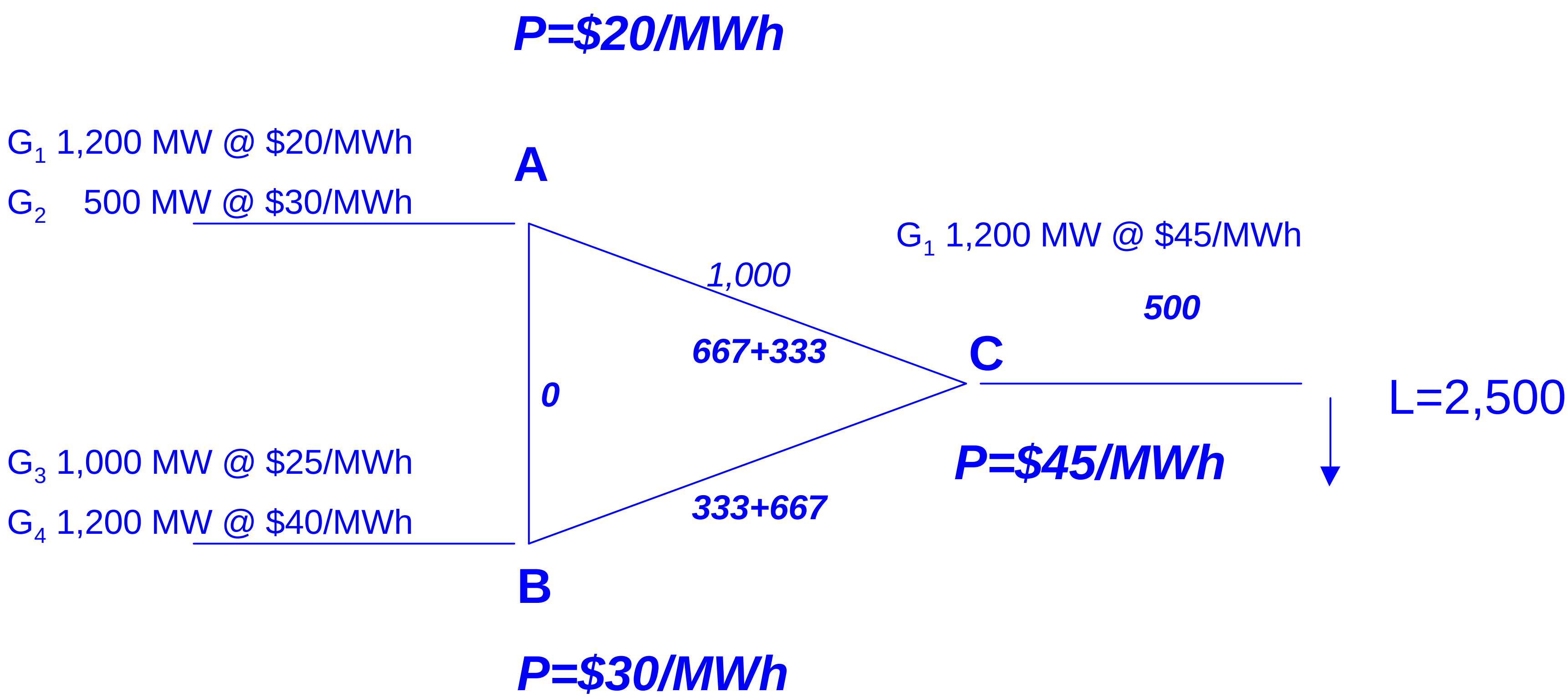
Physical vs. Financial - Example

Constrained



PTR: G_1 holds A-C for value of $5 per MW
FTR: G_1 holds A to C (point-to-point), gets paid $5 per MW ex-post

Physical vs. Financial - Example



PTR: G_1 holds 667 on A-C, and 333 on B-C, G3 holds 333 on A-C and 667 on B-C

FTR: G_1 holds A to C, G3 holds B to C

How Financial Rights Work

- A Financial Hedge against the ex post calculated LMP
- Purchased in advance / Auctioned in advance / Allocated in advance
- Because you flow first and calculate second the overall system will minimize the total cost of all transactions that are scheduled

- If you use the paired nodes you pay the LMP and the system operator gives you the money back (the earnings from the FCR / TCC)
- If you do not use the paired nodes you earn the value of the paired nodes (someone else has used them and paid)
- If you use another pair you pay the LMP for that pair and earn the LMP from the FCR / TCC that you hold

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)

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.**

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Zonal Pricing - Key Principles

- Energy Market separate from a market for transportation
- Physical Rights based - Advanced price and operational certainty
  - Greater than 24 hours
  - Not merely a price hedge
- Market simplicity and transparency
- Maximal opportunity for decentralized decision-making by market participants

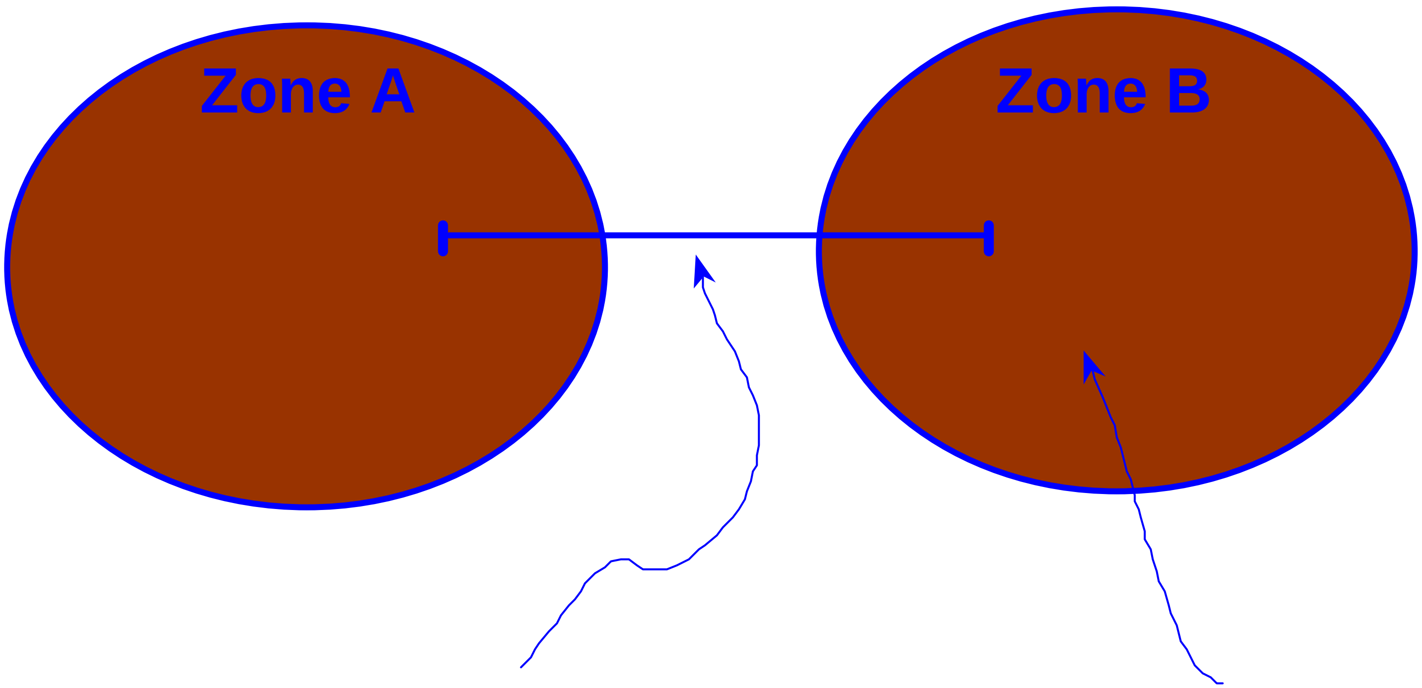
Zonal Pricing - Key Principles

- The underlying operation of the grid is the same, whether one uses the detailed model or the zonal equivalent model
  - The difference is the superposition of the zonal equivalent model onto the detailed model for commercial purposes
  - This is no different than in any other industry - FedEx, airlines, gas transport
- This approach enables the transmission customers to conduct their business insulated from many of the details of system operations (no different than in any other industry)

What's the difference?

- The key difference is in the final settlement and the impact on the value of transmission rights
  - Physical-zonal: price-setting in advance by market players, no payments by RTO to rights holders
  - Financial-nodal: ex-post price-setting by a model, payments from RTOs to rights holders
- The physical-zonal model increases market liquidity and certainty.

The Simple Zonal Model

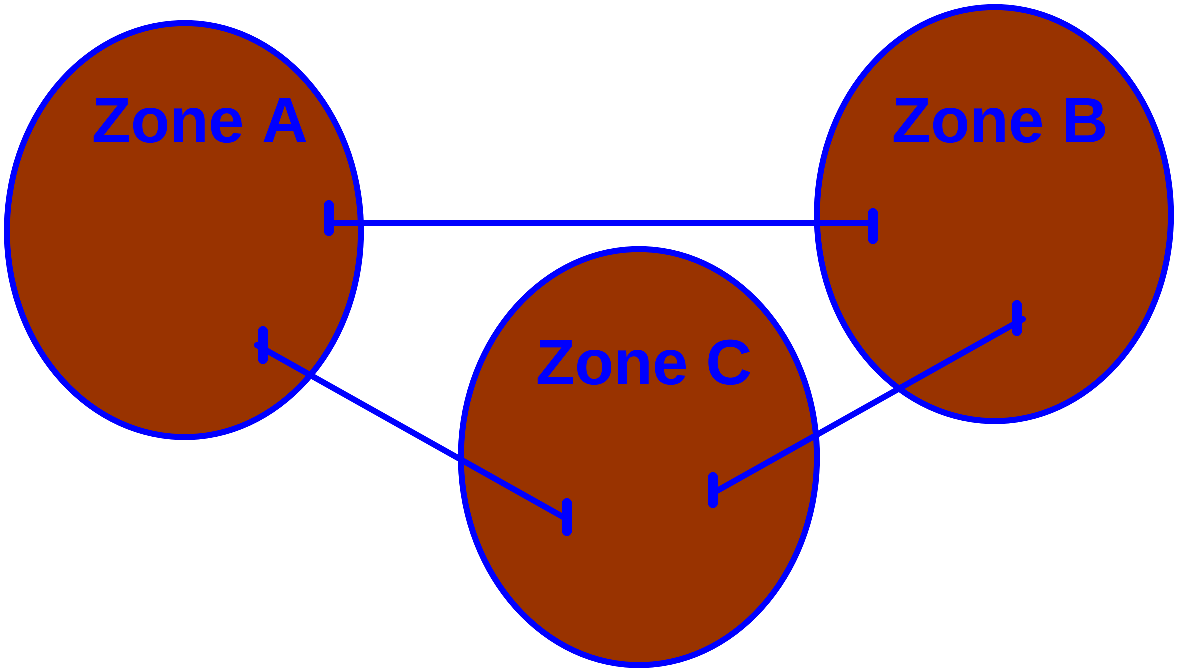


Inter-zonal access: grid user buys a right (FTR) to transport energy from Zone A to Zone B. (Individual grid users bear costs.)

Congestion within a zone: managed by the grid operator; costs are spread across all loads (not borne by individual users).

The Flowgate/Zonal Approach

In a meshed network with loops, zones would be defined using flowgates and node clusters based on distribution factors on those flowgates



Implementation: Zone Definitions

- Define facilities that experience commercially-significant amounts of congestion
  - "Inter-zonal interfaces" (CA ISO, MW ISA, DSTAR)
  - "Commercially significant constraints" (ERCOT)
  - Flowgates (APX, NW RTO?)
- Cluster nodes into zones based on an expectation of uniform prices within zones or based on shift factors
  - For any system condition the distribution factors provide the measure of the quantity of any 'from/to' transaction that passes through any other designated flowgates in a network
  - Distribution factors are generally stable with respect to generation and load
  - Distribution factors are sensitive only to major changes in topology

Zone Definition Methods

Nodes can be clustered to form zones based on either nodal price similarity or impact of generation on potentially constrained power flow.

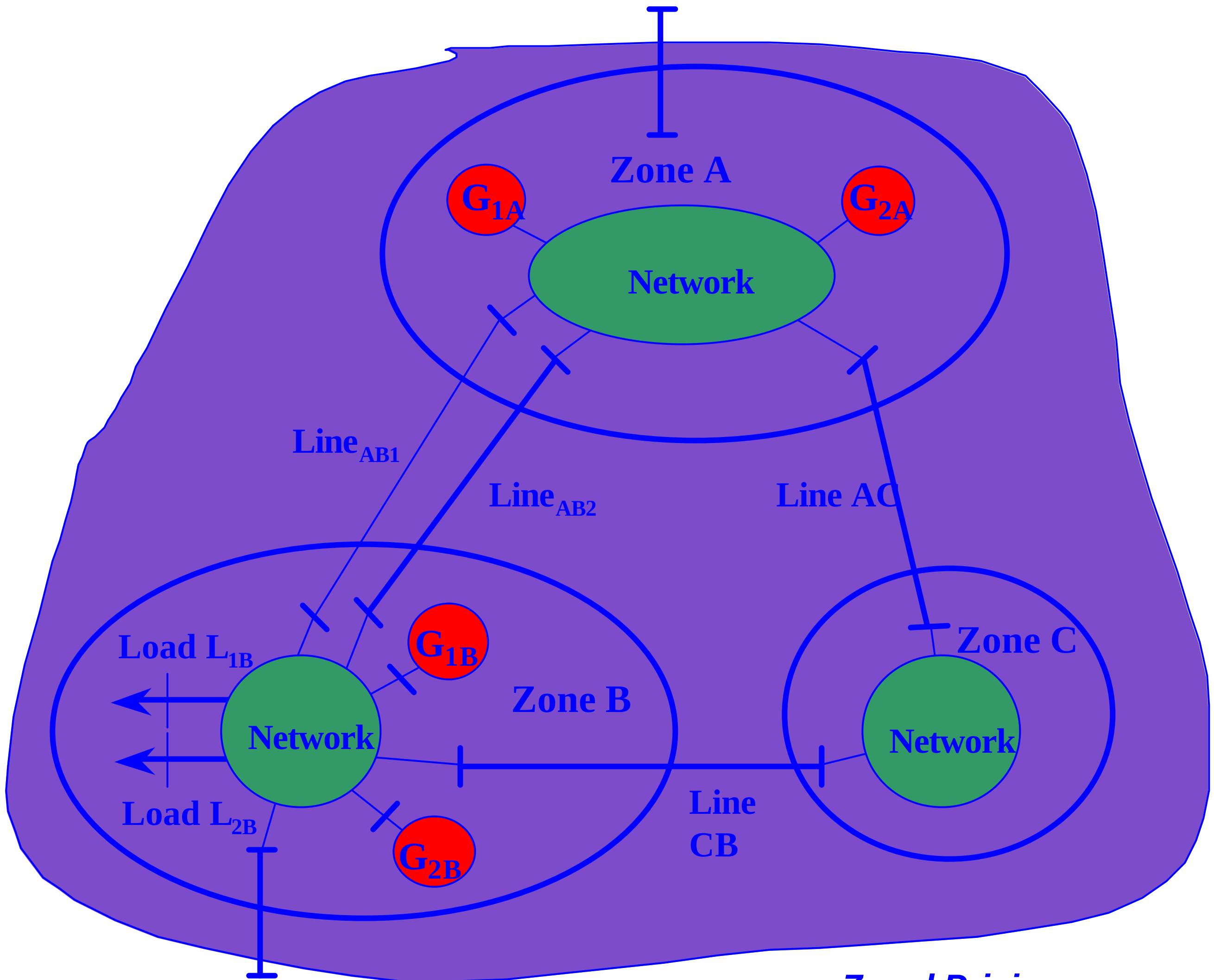
- **Shift factor-based:**
  - **Locations with similar (within a small range) shift factors on all potentially binding constraints are clustered into a single zone (we modeled the entire eastern interconnect transmission system).**

- **Locational price-based**
  - **Nodal price clustering: Locations with hourly prices that fall within a small range of each other for a major portion of the time are clustered into a single zone.**

Clustering - Price vs. Shift Factor

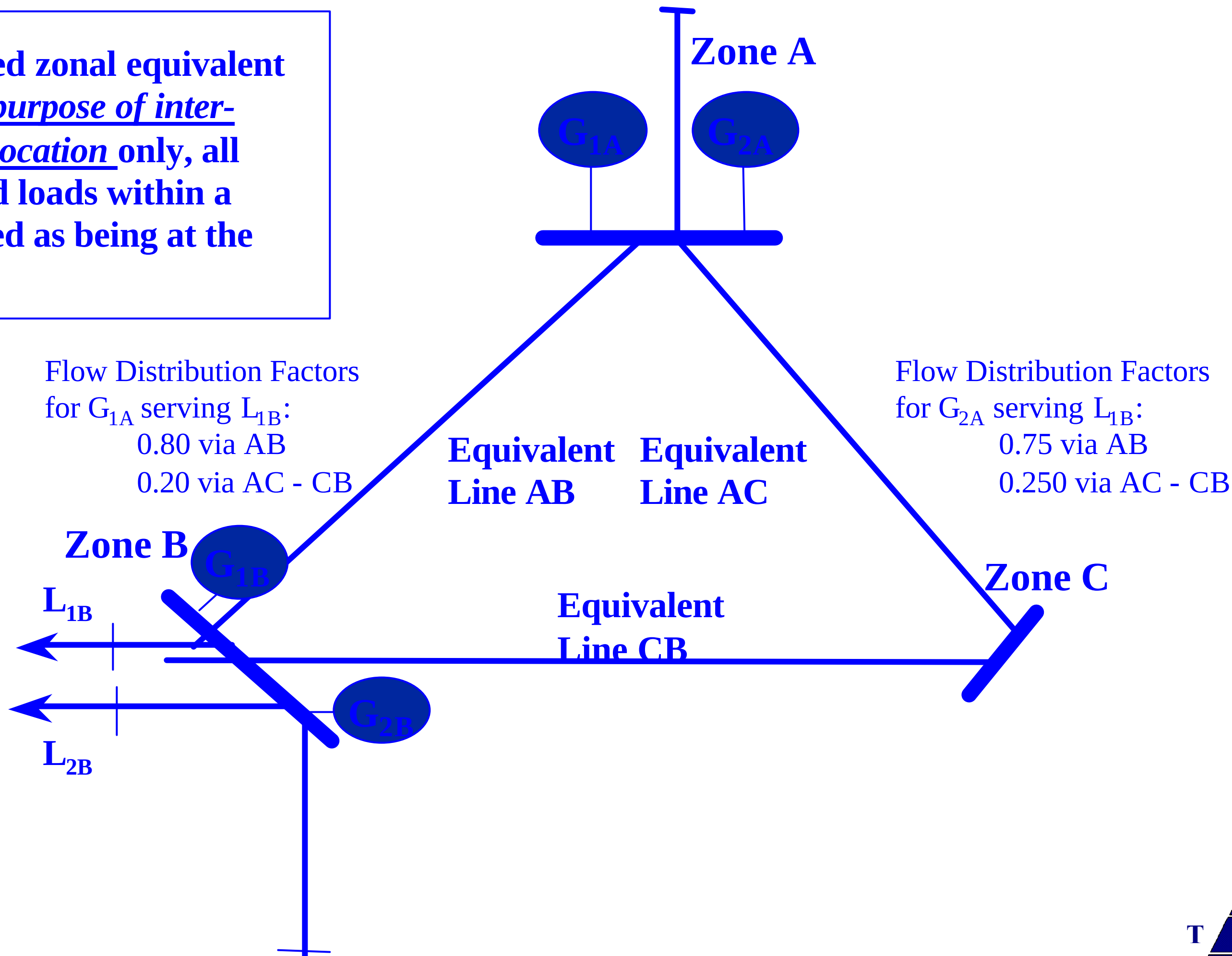
- The choice between the two clustering approaches depends on the dynamics of the pattern of congestion and the attitude towards zone boundary stability.
- The advantages of the price clustering approach are the following:
  - Reflect geographic and economic differences in generator operating costs
  - Potentially binding constraints are weighted based on the percent of time they bind (this is not the case in the shift-factor approach)
  - Do not have to select 'commercially significant" constraints
- The disadvantages of the price clustering approach are:
  - The clustering is dependent on a certain configuration of flows, and may not be robust (e.g., if followed by retail choice)
  - Have to run a centralized OPF, which is halfway to a nodal system
- In our experience, both methodologies yield almost the same zone definitions.

Operations Model of the Grid



Commercial Equivalent Model

Using a reduced zonal equivalent model *for the purpose of inter-zonal rights allocation* only, all generators and loads within a zone are treated as being at the same location.



Implementation: Scheduling

- The marketplace operates continuously clearing exchanges for energy, transmission rights and ancillary services
- These exchanges operate up to the hour-ahead scheduling deadlines
- Market participants use these exchanges (and bilateral trades) to acquire transmission rights, or to make buy-sell arrangements in lieu of transmission rights
- The RTO has no role in forward ancillary services markets, except as “provider of last resort” and for unanticipated real-time conditions
- The RTO posts transmission losses requirements and ancillary services obligations well in advance of the scheduling day

Implementation: Scheduling

- The RTO operates a day-ahead scheduling *process*, not a "day-ahead *market*"
  - Participants must submit *balanced schedules* to the RTO: production + transportation = consumption
    - » Injections + allocated transmission losses = withdrawals + trades to other Participants
    - » Participants must submit FTRs which correspond to the Participants's use of inter-zonal interfaces or flowgates
    - » Participants encouraged - but not required - to self-provide their pro rata shares of ancillary services requirements
    - » Unbalanced schedules are rejected
    - » The RTO does *not* "accept all schedules" - i.e., the RTO does *not* broker trades between various Participants

Implementation: Real-Time & Beyond

- **The RTO will operate a real-time balancing market**
  - The RTO continually balances injections and withdrawals to meet NERC control performance standards
    - » RTO relies on balancing energy obtained from ancillary service stacks and supplemental energy bids
  - RTO will grant changes as long as they do not cause congestion, and charge non-punitive penalties for large imbalances
  - Participants may trade their imbalances after the fact

Design Issues

- How do you define the flowgates/zones?
- How stable are the flow distribution factors?
- How should you trade off 'commercial simplicity' with the gap between the commercial and operations?
- Should you have central dispatch in real-time?

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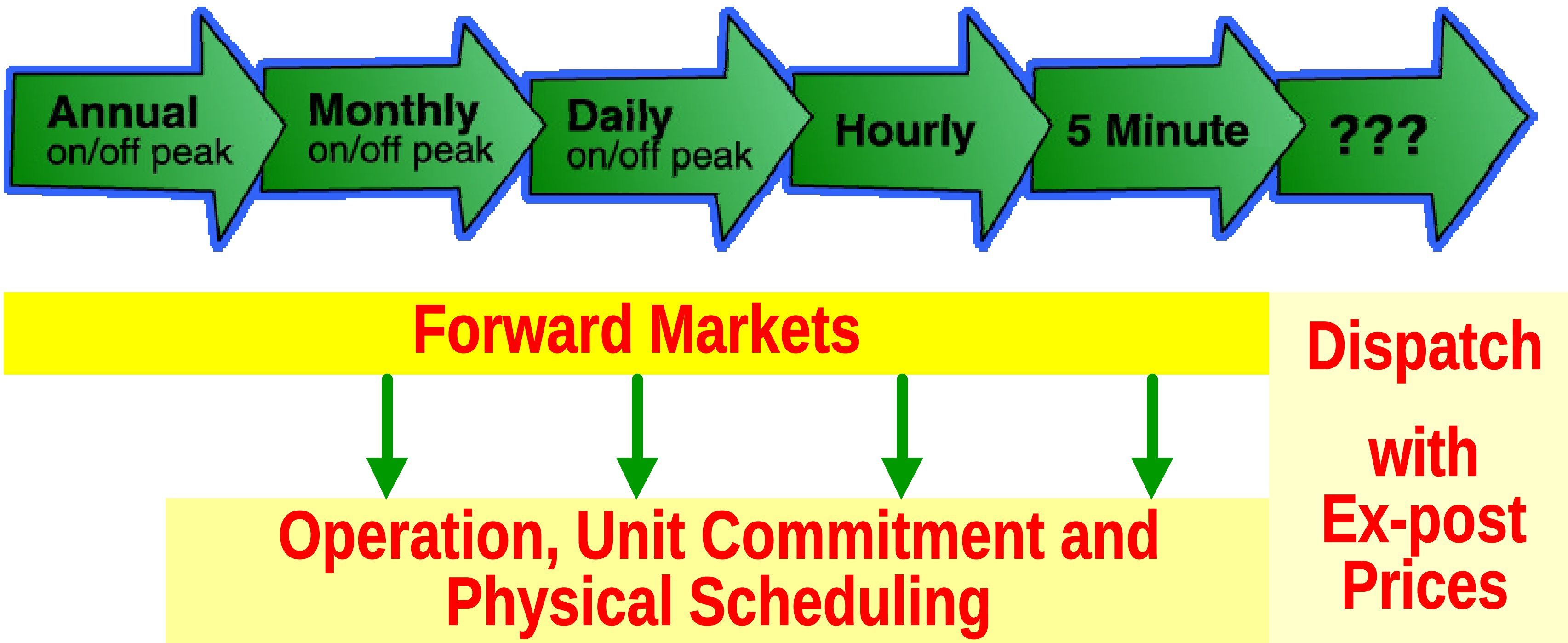
Flow-based Pricing

As in the zonal model, the flow-based pricing model seeks to eliminate the role of the RTO in forward markets, using physical rights and bilateral markets. However, in real-time, either ex-post nodal or zonal prices in balancing markets can be calculated.

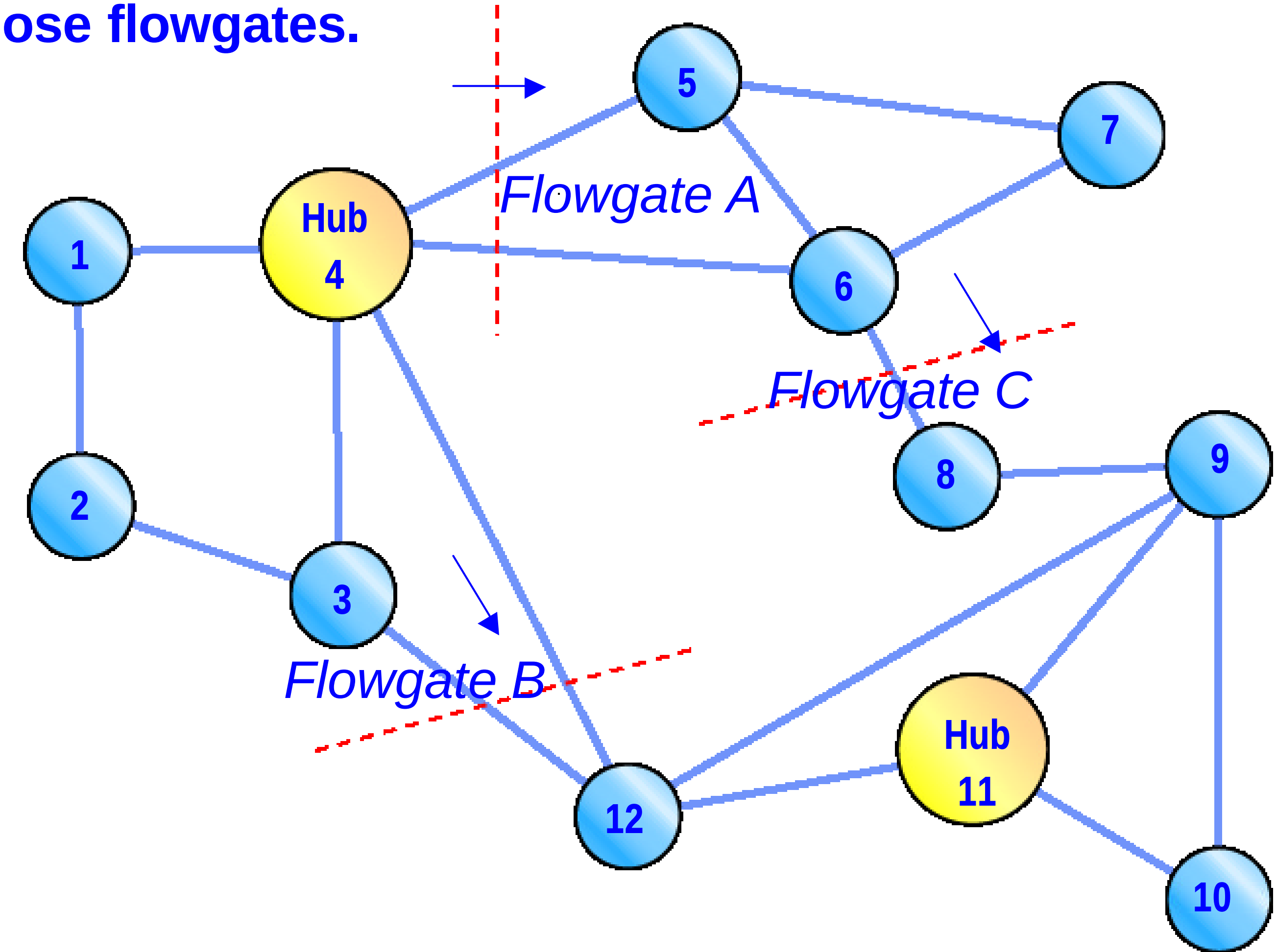


Defining Capacity Rights

Every transaction would have to purchase rights on "commercially significant" flowgates based on the contribution of flows (shift factors) by the transaction on those flowgates.

Bus to Hub 11 Flow Factors

	Flowgate		
Bus	**A**	**B**	**C**
1	0.70	0.30	0.30
2	0.80	0.20	0.20
3	0.90	0.10	0.10
4	0.60	0.40	0.40
5	0.60	-0.60	0.40
6	0.50	-0.50	0.50
7	0.55	-0.55	0.45
8	0.20	-0.20	-0.20
9	0.05	-0.05	-0.05
10	-0.01	0.01	0.01
11	0.00	0.00	0.00
12	-0.05	0.05	0.05



Courtesy of REAL FLOW Task Force

Seamless RTO Designs for the Matured Market

The flowgates and shift factors are centrally generated at NERC, thereby allowing for the seamless use of this scheme across multiple RTOs.

- ***Forward*, bilateral and exchange interconnection-wide markets for energy, transmission and ancillary services seamlessly transitioning to a set of sub regional *dispatch* procedures near delivery.**
- ***Forward* markets allow coordination over the entire interconnection for generation, transmission and buyer decisions.**
- ***Dispatch* procedures allow coordination of frequent, closely coupled decisions with short decision lead times.**

Advantages and Disadvantages of the Flow-based Approach

The advantages of the flow-based method are:

- Enables integration across RTOs
- Promotes efficient, bilateral markets for energy, capacity, and ancillary services
- Flexible enough to work with both zonal and nodal real-time pricing
- In the case of APX's implementation, uses 'e-commerce' to enable efficient, multi-lateral trading with minimal transaction costs.
- Accounts for loop flows in large networks

The disadvantages of the flow-based method are:

- Requires the definition of 'commercially significant' flowgates.
- Difficulties in managing physical capacity rights, such as determining risk-sharing of real-time loss in capacity between RTO and the market.
- Transactions can get complicated across large regions
- Transition to and coordination between forward markets and real-time market is not well defined.

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LUNCHTIME

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Pricing Method and Property Rights

	Nodal Pricing	Zonal Pricing
Financial Rights	• Examples: PJM, NYPP, proposed in NEPOOL • Outcome of ex-post centralized dispatch calculation	• Example: California
Physical Rights	• Same as financial in a perfectly competitive market • Hard to define in LMP system, due to loop flows	• Proposed in Desert Star, Mountain West ISA

Zonal - Nodal Comparison

- **Advantages and Disadvantages in:**
  - **Theoretical Efficiency**
  - **Implementability**
  - **Market Activity**
  - **Price Signals for future investment**
  - **Cost causation**
  - **Retail competition**
  - **Market structure (tight vs. loose pools)**
  - **Equity**

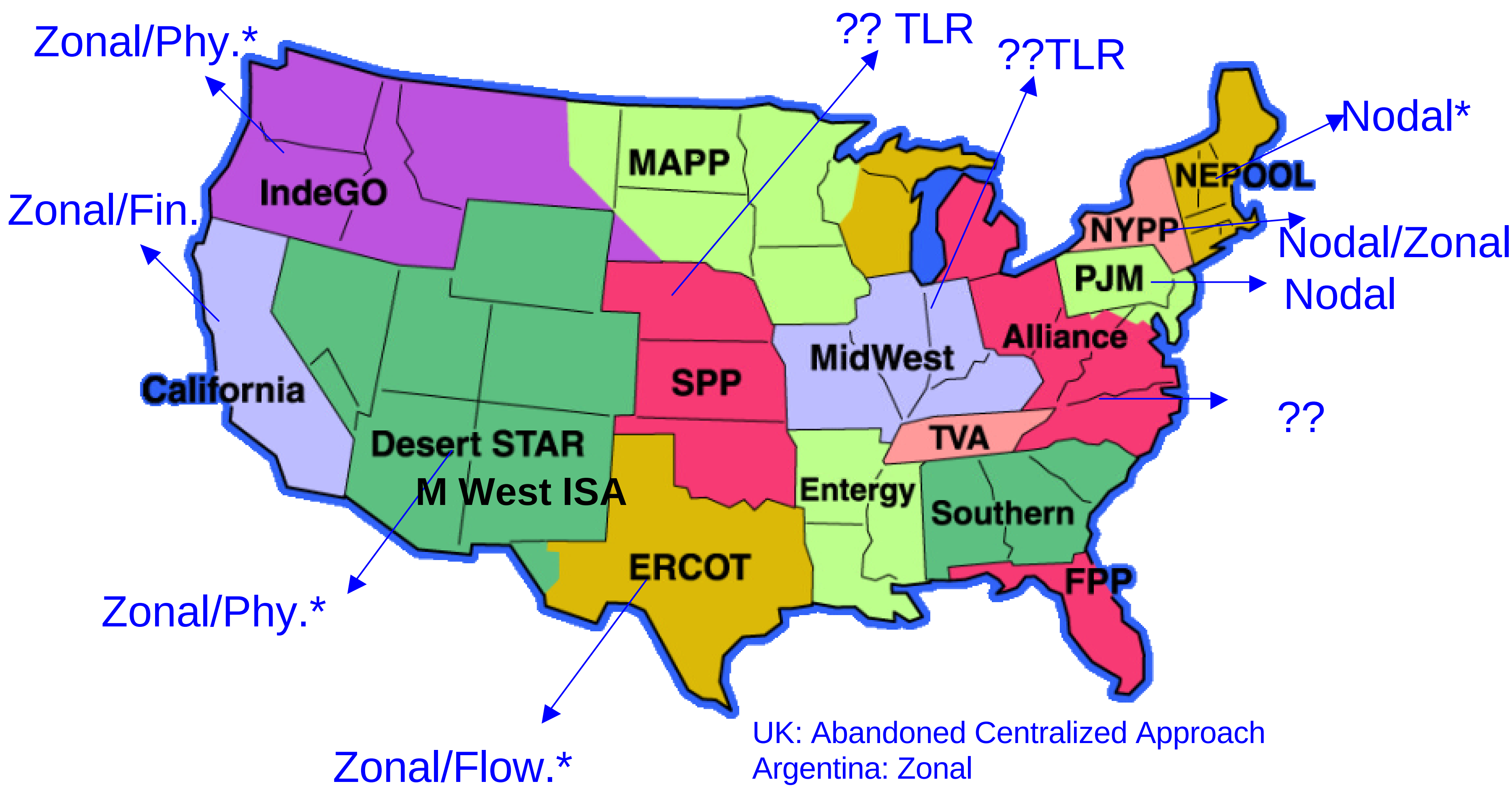
Comparison of Congestion Pricing Mechanisms - Objectives

	Nodal	*Zonal*	*Flow-based*
Theoretical Efficiency	• Sound in theory, in practice dependent on software and input assumptions.	• Accurate with rounding error, region dependent.	• Accurate pricing, dependent on efficiency of energy markets.
Implement ability	• Centralization costly. Mixed results in reality - more suitable for 'tight' pools.	• Zone definition/ constraint selection not an exact science, more suitable in 'loose' pools.	• Selection criteria required for 'commercially significant' constraints.
Market Activity	• Complexity and unpredictability are barriers to entry. Can discourage bilateral activity in practice.	• Encourages bilateral trading, Market participants set price of transmission.	• Encourages bilateral trading, Market participants set price of transmission.

Comparison of Congestion Pricing Mechanisms - Objectives

	Nodal	*Zonal*	*Flow-based*
Cost Causation	• Accurate, within limits of assumptions, highest level of granularity.	• Accurate with well-defined zones, region dependent.	• Accurate with appropriate constraint selection.
Future Investment	• Provides right signals, deters creation of 'local' congestion.	• Provides right signals, but with less granularity.	• Provides right signals, but with less granularity.
Retail Access	• Complexity and ex-post pricing can hinder retail participation.	• Effective, because of limited pricing areas	• Effective, because of limited pricing areas
Equity	• Can lead to inequitable outcomes at a local level	• Equitable in the absence of significant intra-zonal congestion.	• Equitable in the absence of significant intra-zonal congestion.

Congestion Management Across the US and Beyond



UK: Abandoned Centralized Approach
Argentina: Zonal
Australia: State-based zonal
New Zealand: Nodal/No FTRs
Norway: Zonal

***Proposals**

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New York

- Participant bid structure
  - ISO centralized market
    - » Generators multi-part bids: start-up costs, incremental energy bids, minimum load
    - » Loads submit load forecasts and bids (including price-sensitive)
  - Bilateral market
    - » Schedules submitted day-ahead include: quantity, points of injection and withdrawal, decremental bids (used by ISO in real-time market for balancing), but currently limited to generators and LSEs
- Settlement mechanism
  - Day ahead and real-time markets for energy and A/S
    - » ISO computes locational prices, congestion costs and marginal losses using model of the system
  - Generators receive nodal price (+ Uplift)
  - Load pays zonal average price (11 Zones)

New York: Pros and Cons

- **Pros**
  - Effort to create highly sophisticated, model-based market clearing system
    - » Two-settlement, LBMP, TCCs, Losses …
- **Cons**
  - Today market is totally dysfunctional
    - » Clearing prices are not correlated
    - » Price volatility is not forecastable
    - » Market clearing / billing software non functional
    - » Limited player access
    - » No apparent liquidity

Mid-Atlantic: PJM

- **Current settlement mechanism**
  - **Day –ahead and Real-time settlement markets and settlement systems**
  - **Generators receive nodal real time energy price (+ uplift to cover market revenue shortfalls and ancillary services)**
  - **Load pays either nodal or bus aggregate price**
  - **Load pays daily ancillary service charges**
  - **Price cap of $1000/MWh remains in effect**
  - **Regulation will be explicit market**

Mid-Atlantic: PJM Pros and Cons

- **Pros**
  - **Information system (OASIS) is spectacular**
  - **Market model is explicable, functional and reproducible**
- **Cons**
  - **LMP has eliminated some forward market products**
  - **Trading occurs only at Western Hub**
  - **Complexity of LMP has moved risk of delivery to only the final supplier who is currently protected (somewhat) by the FTR allocation procedures**

Market Structures - Northeast ISOs

The Northeast markets (NEPOOL, NYPP and PJM) have all evolved together with ISOs and have similar market characteristics.

- They all have ISOs that administer a power exchange (PX) as well as operate the transmission system.
- They all (currently) have installed capacity markets separate from energy that are administered by the ISOs.
- They will all eventually implement LMP-based congestion pricing
- They all currently allow bilateral transactions

Market Structures - Northeast ISOs

However, Northeast markets have significant differences, particularly between NEPOOL and the other two markets.

	NEPOOL	NYPP	PJM
Settlement	• One real-time market, but plan a two-settlement system by late 2001	• A day-ahead and a real-time energy market	• Real-time market, and day-ahead market implemented in June 2000.
Reserves	• Separate markets for oper. reserves (including spinning and non-spinning reserve)	• (same as New England) going through major changes.	• Currently no explicit reserves markets, but plans for explicit markets.
Congestion Management	• Congestion costs are currently socialized; nodal congestion management model with FCRs planned for late 2001	• Congestion management uses zonal-nodal model with TCCs; expected to move to full-nodal	• Congestion management uses nodal-based model and FTRs
Capacity Markets	• Single installed capacity market, will be eliminated by 2001, **and maybe earlier**.	• Locational installed capacity markets	• Single capacity market with Capacity Interchange Rights

Regulatory Risks

All the Northeast ISOs, particularly NEPOOL, are very much in the process of development and pose considerable risk to market participants.

- In the three markets, the rules are still evolving.
- In NYPP, the reserve markets are being debated.
- In PJM, a new two settlement system has been implemented this June, and separate markets for ancillary services are proposed.
- In NEPOOL (long term):
  - The ICAP market will be eliminated (OP CAP is gone).
  - The definition and allocation of FCRs are currently being debated.
  - The details of multi-settlement and congestion management are not finalized.

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Congestion Management In CA

- California uses combination of rights and redispatch to resolve congestion on commercially-significant paths (interzonal)
- Local congestion (*intra*zonal) is resolved by redispatch, with net costs uplifted to all loads within the affected zone

Firm Transmission Rights

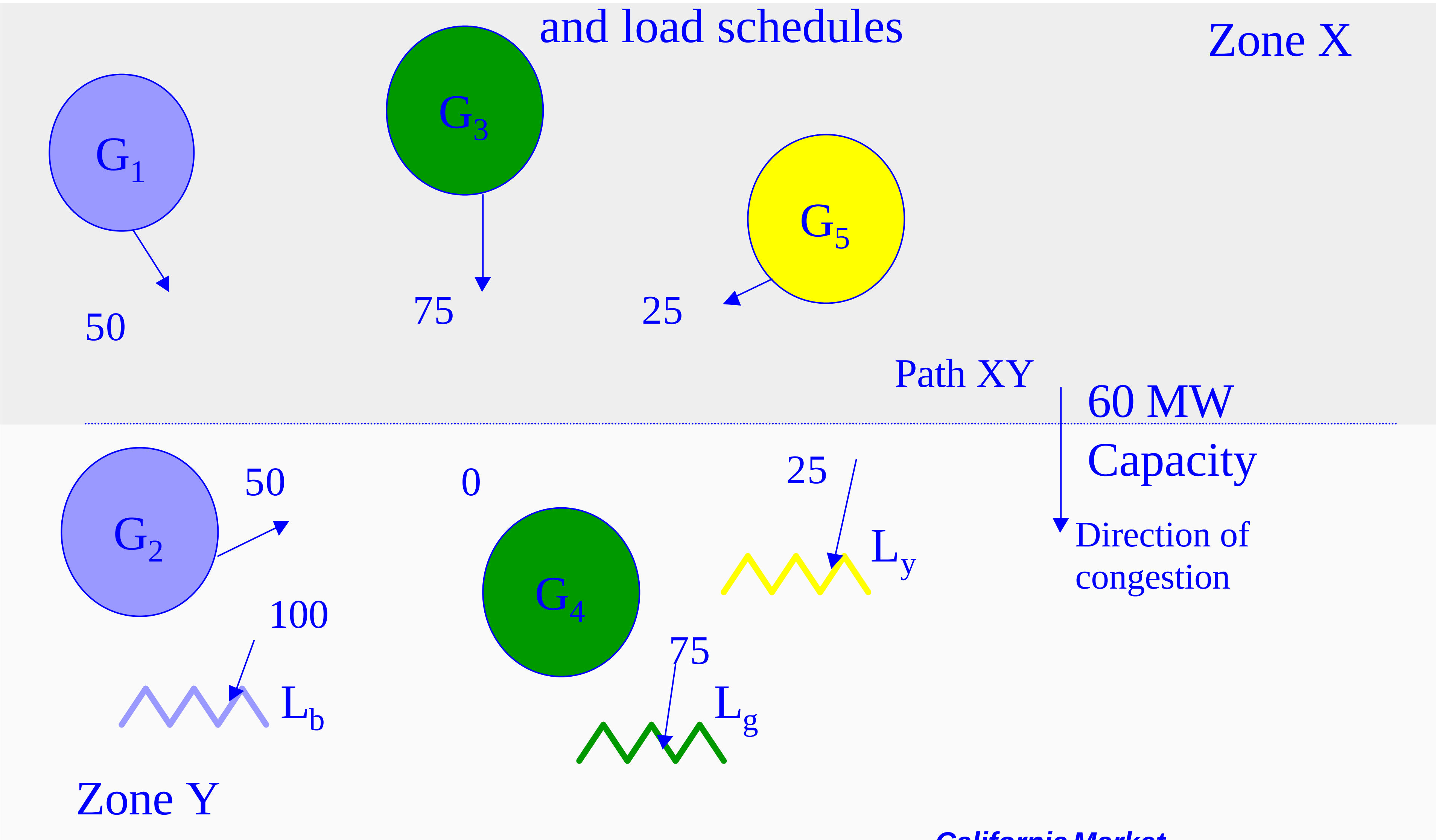
- Rights are auctioned annually for approximately 25% of the ATC of major interfaces into CA and within CA
- Rights are "Firm" as they offer a scheduling priority in the Day Ahead forward market, over scheduled flow, should a path's congestion be economically unresolvable
- Otherwise rights are financial - providing the right to the congestion rents of 1 MW on the path
- Rights are un-directional => no negative value risk to holder
- Rights are divisible and tradable by MW and by hour

Inc and Dec Bidding Otherwise Resolve Congestion

- **Schedule Coordinators can offer to increase or decrease generation or loads as part of their forward balanced energy schedules**
- **Currently a "market separation constraint" lets the ISO only adjust *within* an SC's portfolio to resolve congestion, but will be somewhat relaxed when the ISO implements inc and dec bidding on trades between SCs.**
- **The highest ✍ price between zones required to clear the congestion sets the "congestion price"**

Inc/Dec Example - Initial Schedules

Three SCs (Blue, Green and Yellow) with the following resource and load schedules

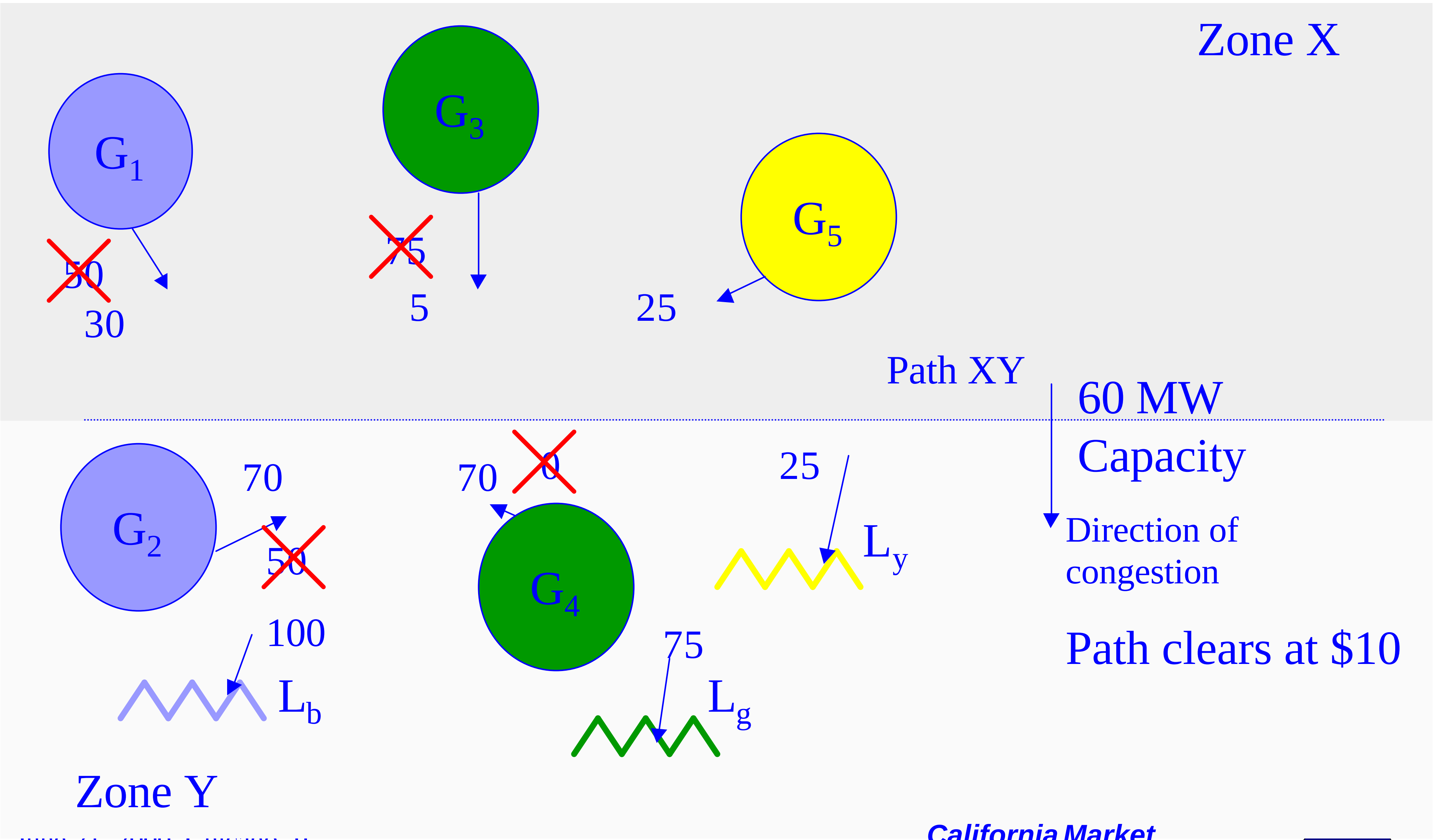


Summary of Schedules and Bids

SC	Resource	Bilateral Schedule	Inc/Dec Bid
Blue	G1	50	Dec 20@ $20
Blue	G2	50	Inc 20@ $25
Blue	Lb	100	none
Green	G3	75	Dec 75 @ $30
Green	G4	0	Inc 75 @ $40
Green	Lg	75	Dec 25 @ $50
Yellow	G5	25	none
Yellow	Ly	25	none

- Yellow was a price taker, they use 25 MW of the path and will pay the clearing price
- Blue values the path at $5, they use 30 MW of the path
- Green values the path at $10- $20, they use the remaining 5 MW
- The path clears at the marginal value of $10 (Green's bid which just cleared the congestion)
- Blue and Green pay and are paid $10 net to redispatch; yellow & green pay $10 for usage

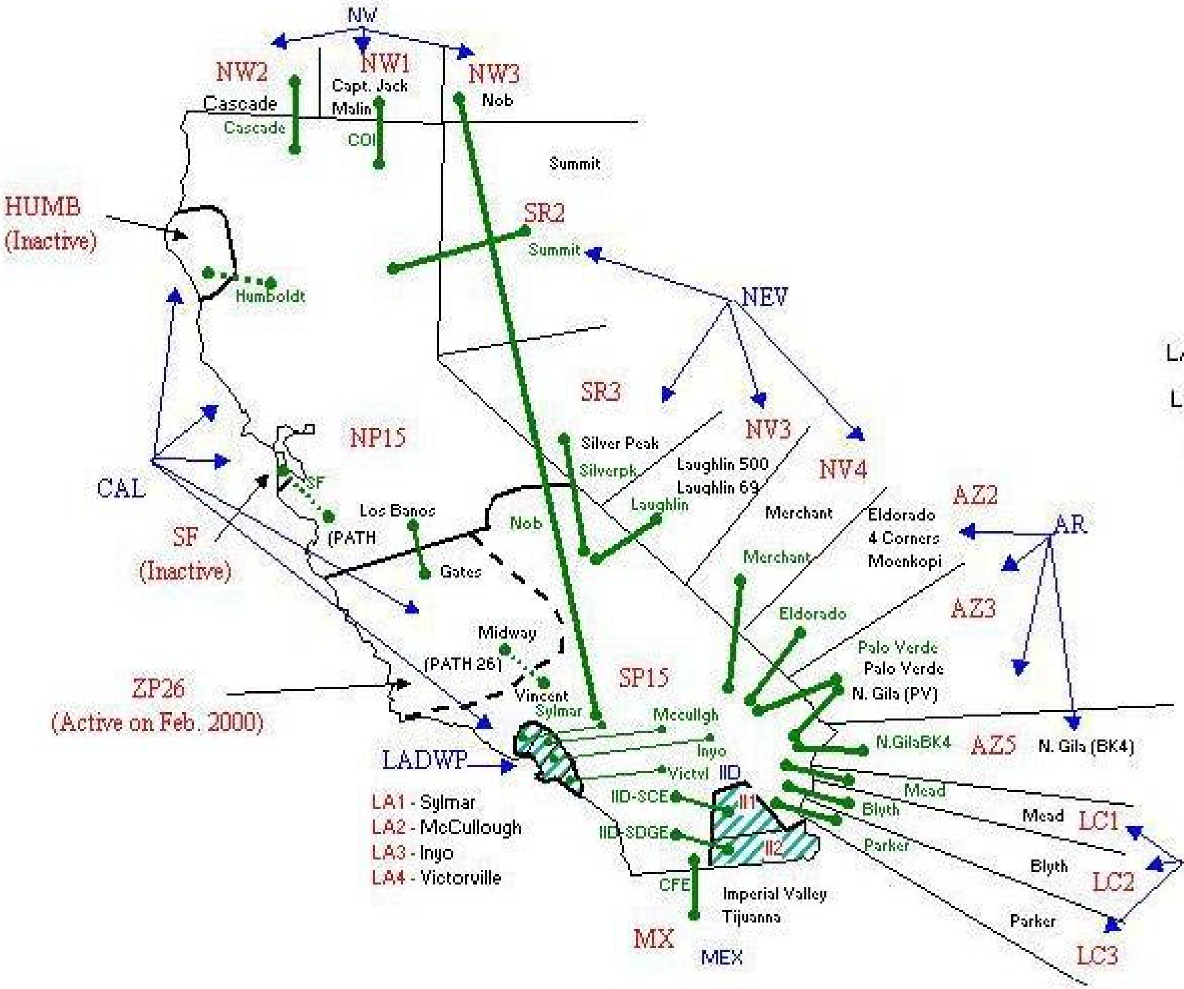
Inc/Dec Example - Final Schedules

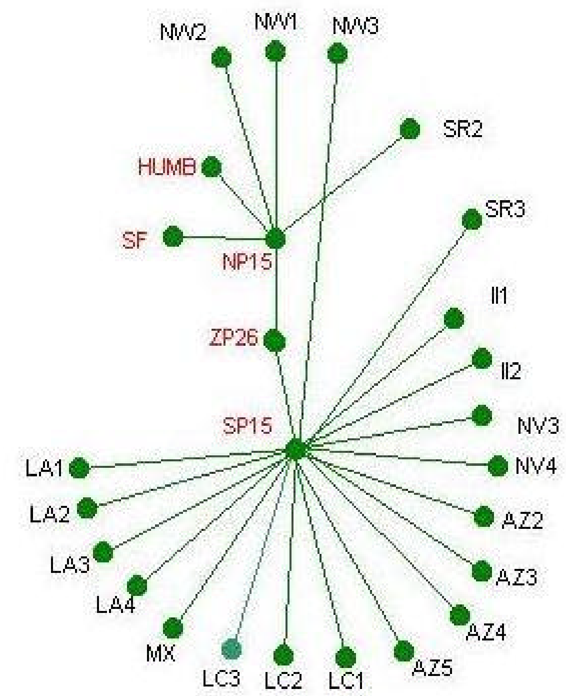


Cal PX applies CA ISO Congestion Charges

- The Cal PX runs its day ahead market assuming no congestion and arrives at a single Unconstrained Market Clearing Price
- Once the ISO's determined the congestion prices the PX adjusts its zonal prices such that the differences are exactly equal to the respective ISO congestion prices
- With the previous example the PX clearing price in Zone Y would equal the PX clearing price in Zone X + $10

California Market - Zone Boundaries





CA ISO Monthly Day Ahead Congestion Prices

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	-	-	-

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Alternatives to Nodal and Zonal

- The status quo in the Midwest with a better congestion management system (market based system instead of TLRs) is an alternative
- Flow- Based congestion pricing with complete bilateral markets is another alternative
- A hybrid system of zonal-financial where all financial transactions settled on a zonal basis until they reach the point of physical delivery, then they are settled on a nodal basis
- Some of the above alternatives might coexist or necessitates a zonal or a nodal pricing systems !!!

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What About the Midwest - Discussion

- The Midwest system is characterized by large number of control areas, significant transmission congestion in some parts, history of loose cooperation in dispatch and pooling resources, and wide geographic area.
- This suggests a less centralized system than can be implemented in tight pools, that is if we want a workable and affordable market in the near future.
- What are the right ISO/RTO boundaries?
- Can we resolve the known problems with the current system? Specifically the congestion management system.
- Can we adopt a step-wise approach?