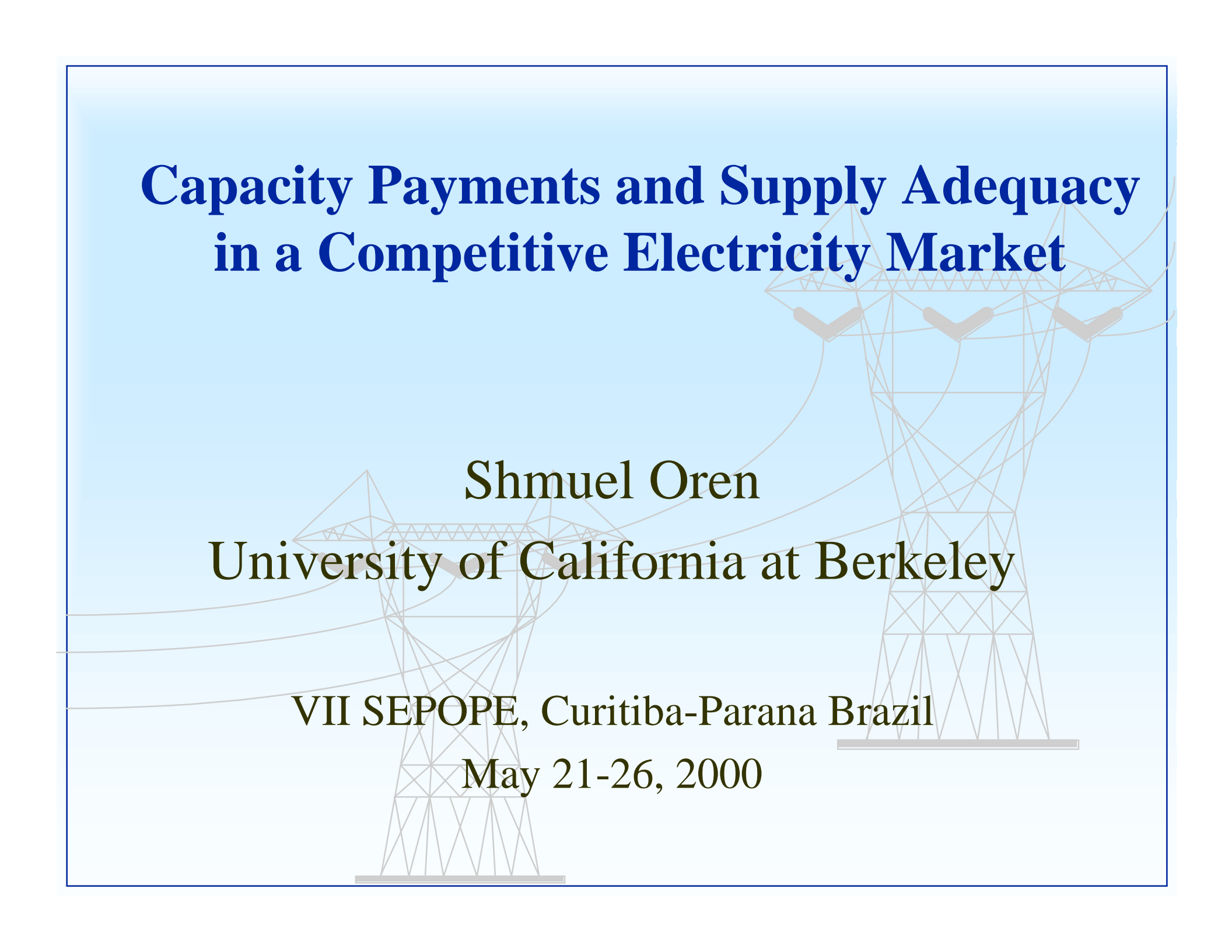


Capacity Payments and Supply Adequacy in a Competitive Electricity Market



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VII SEPOPE, Curitiba-Parana Brazil

May 21-26, 2000

What is Reliability

- NERC (National Electric Reliability Council) defines reliability as: “the degree to which the performance of the elements of the electrical system results in power being delivered to consumers within accepted standards and in the amount desired”
- Reliability encompasses two concepts:
 - **Security:** “the ability of the system to withstand sudden disturbances.” This aspect concerns short-term operations and is addressed by *ancillary services* which include: Voltage support, Congestion relief, Regulation (AGC) capacity, Spinning reserves, Nonspinning reserves, Replacement reserves.
 - **Adequacy:** “the ability of the system to supply the aggregate electric power and energy requirements of the consumers at all times”. This aspect concerns planning and investment and is addressed by Planning reserves, Installed capacity, Operable capacity or Available capacity.

Markets and Reliability

- Security and Adequacy are both compliments and substitutes.
- Security is a *public good* while Adequacy is mostly a *private good*.
- Security can be provided through competitive procurement of ancillary services. However, decisions concerning required amounts, dispatch and cost allocation need be centralized due to externalities and free rider effects.
- Generation adequacy decisions can be decentralized and left to the market. Inadequate supply will result in high prices which in turn encourage new capacity. Customers should be allowed to decide how much they want to pay for and suppliers should decide how much to invest. These are individual economic and risk management decisions.

Alternative Approaches to Ensuring Generation Adequacy

- Rely on energy markets. Consumers and suppliers interact through unrestricted energy spot markets. Energy spot and future energy prices provide price signals and compensation for capacity investment. Technology mix and generation capacity are determined by entry and exit of suppliers and by customer choice of desired price risk. (California, Nordpool)
- Central agency (ISO or Regulator) specifies requirements for planning reserves based on traditional planning tools. Capacity market allow supplier to trade reserves and efficiently reallocate the reserves requirements but the capacity market and energy market may not be in equilibrium (PJM, New York, New England)
- Generators receive capacity payments based on availability, technology, VOLL, LOLP to incent investment and availability. (old UK system, Argentina, Spain)

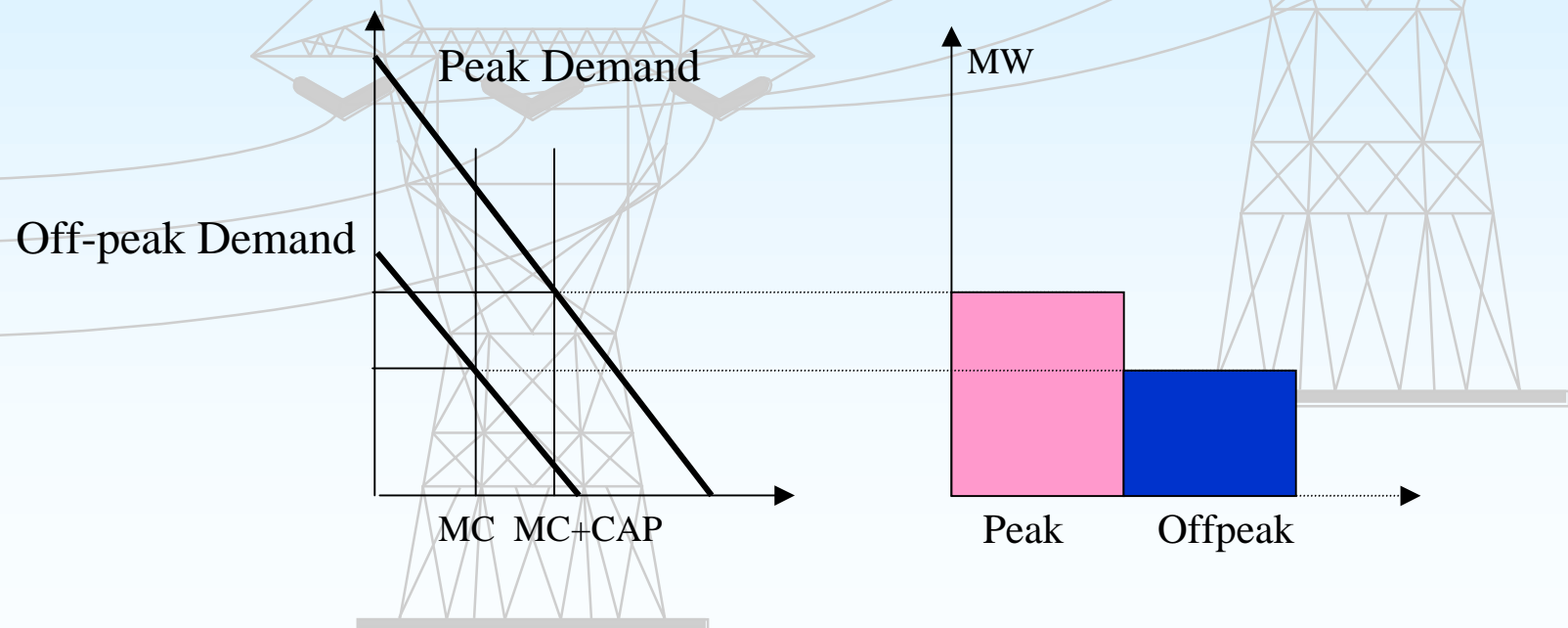
Short-Term Vs. Long-Term Efficiency

- Savings from improved dispatch under restructuring not likely to be high (system operated quite efficiently).
- Most efficiency gains from restructuring will be long-term resulting from better investment decisions (technology choice, location and generation capacity) and from demand side response to price signals.
- The economic process that leads to long-term efficiency involves entry and exit in response to energy price signals, and customer choice of desired supply certainty and price risk.
- Centrally determined installed capacity requirements or capacity payments interfere with this economic process.

The Theoretical Foundation of Capacity Payments

Payments

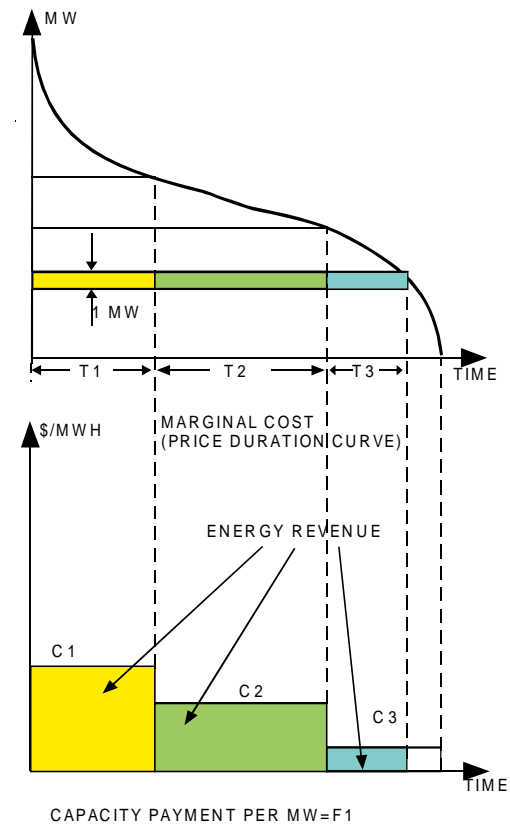
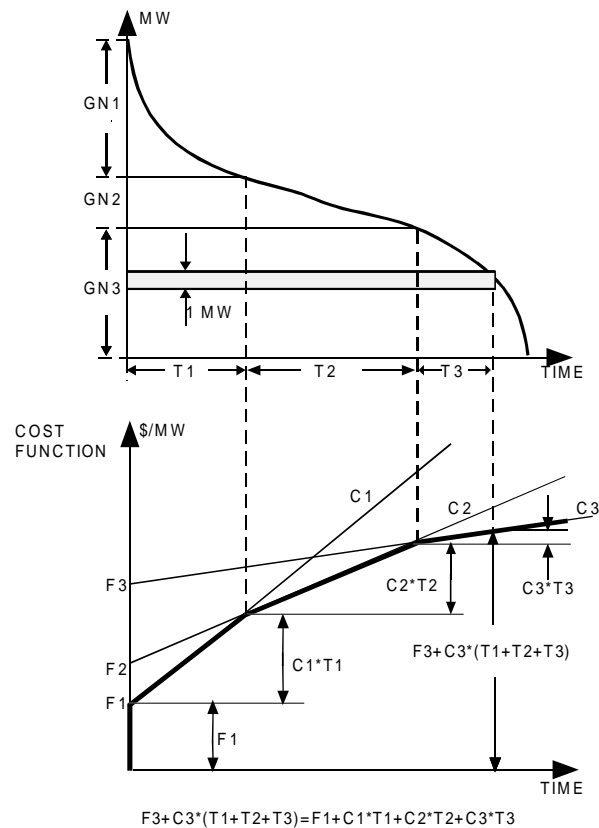
- Capacity payments originate in the theory of peak load pricing (Boiteux)
 - *Basic Idea:* There are two commodities, energy and capacity. The objective of pricing is to recover cost while minimizing distortion of efficient consumption. Peak load users are responsible for capacity requirements while off peak user only consume energy. Hence, efficient pricing must charge MC off-peak and MC+Capacity charge on-peak.



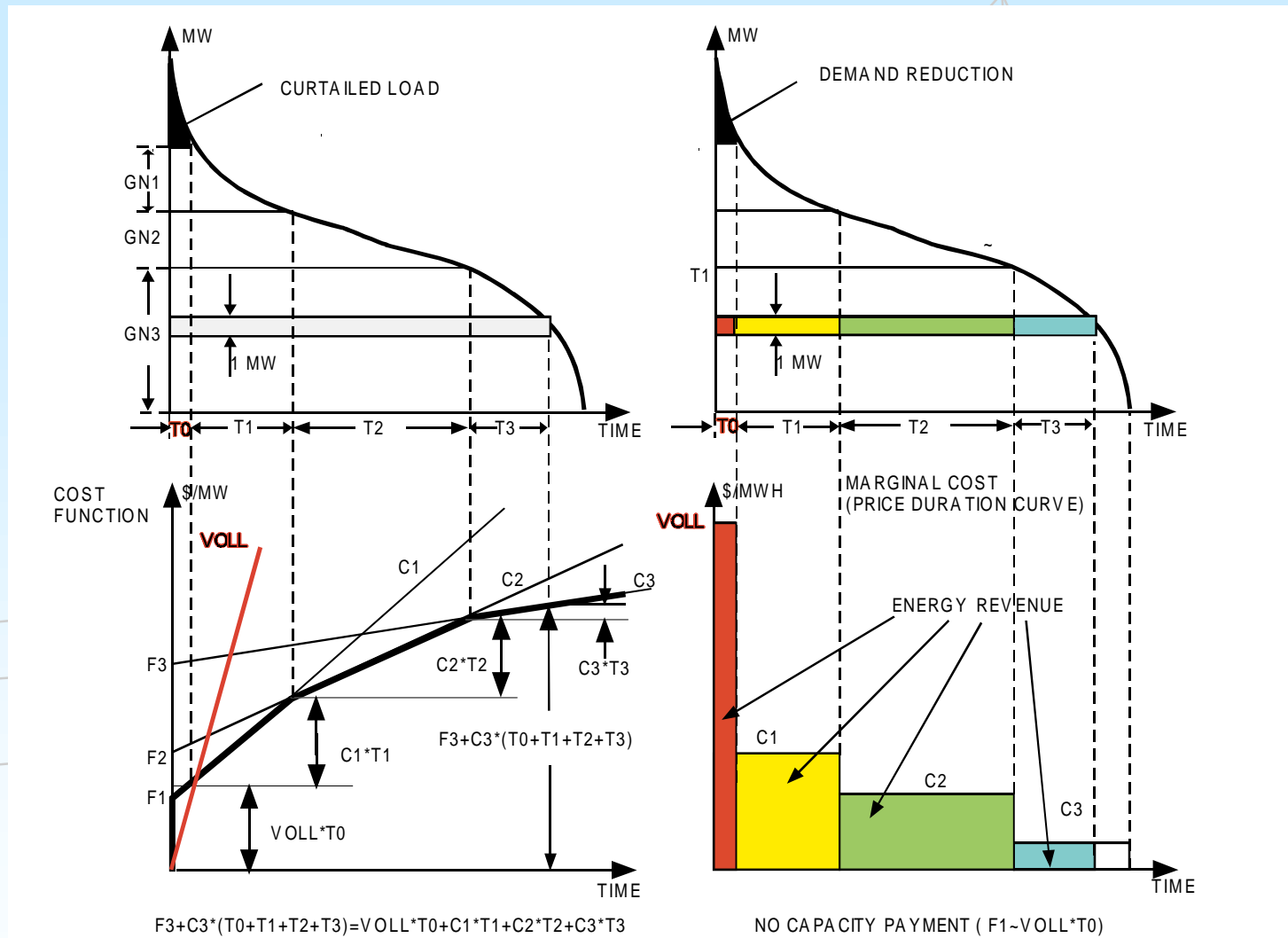
Theoretical Foundation of Capacity Payments: Extensions

- Effect of Uncertainty
 - *Basic Idea:* The two commodities are energy and reliability of supply. Additional capacity increases reliability (reduces LOLP) on and off peak hence capacity cost should be allocated over all time periods so as to reflect the value of improved reliability
- Effect of Multiple Technologies
 - *Basic idea:* Recover production cost with optimal technology mix through a nonlinear price structure based on load factor (Wright tariff) or equivalently through a combination of time of use MC- based energy rate and a demand charge.

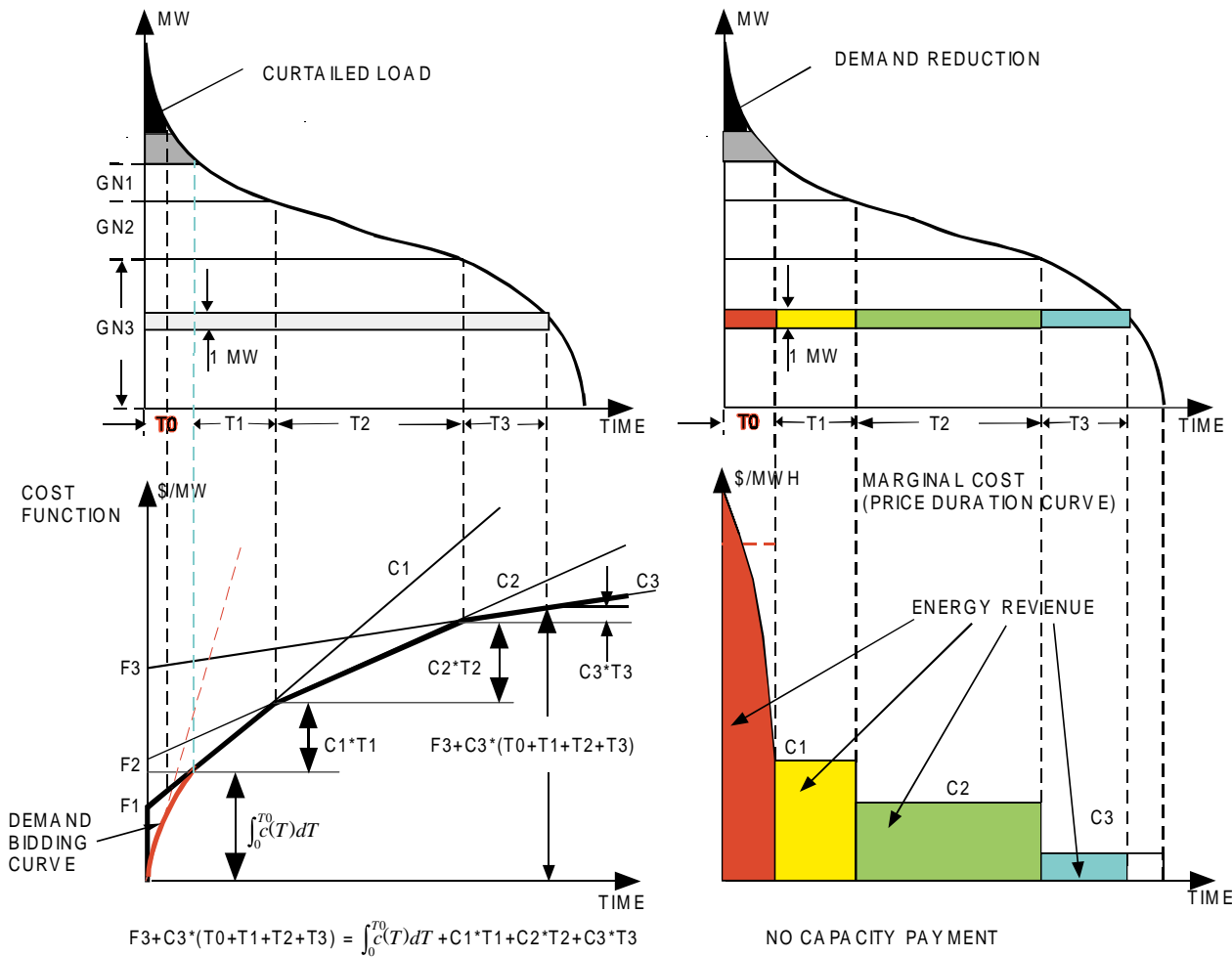
Cost Recovery Through a Combination of Marginal Costs and Capacity Payment



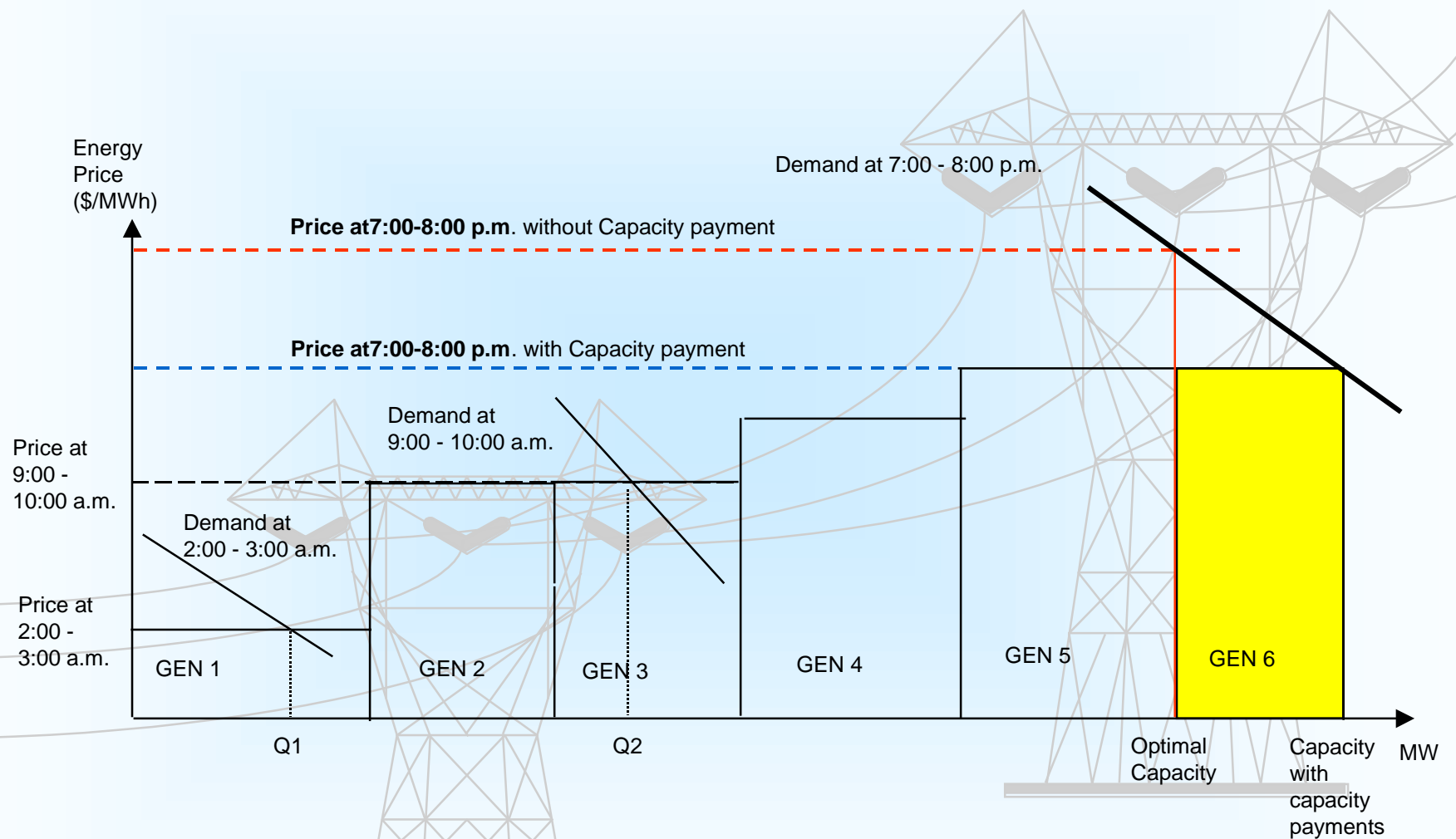
Capacity Payments Covered by Raising Energy Prices to VOLL During Shortage Periods



Demand Side Bidding Provides a Market Based Alternative to Administratively set VOLL



Energy Market With and Without Capacity Market



Example of Long Run Equilibrium in Energy Only Markets

- Supply: Two types of generators

G1: N=50

G2: N=100

Capacity=80MW

Capacity=60MW

FC=\$926,400/Month

FC=\$288,000/Month

MC=\$15/MWh

MC=\$25/MWh

- Demand: Two demand functions

Off-Peak: 420 Hrs./Month

Peak: 300

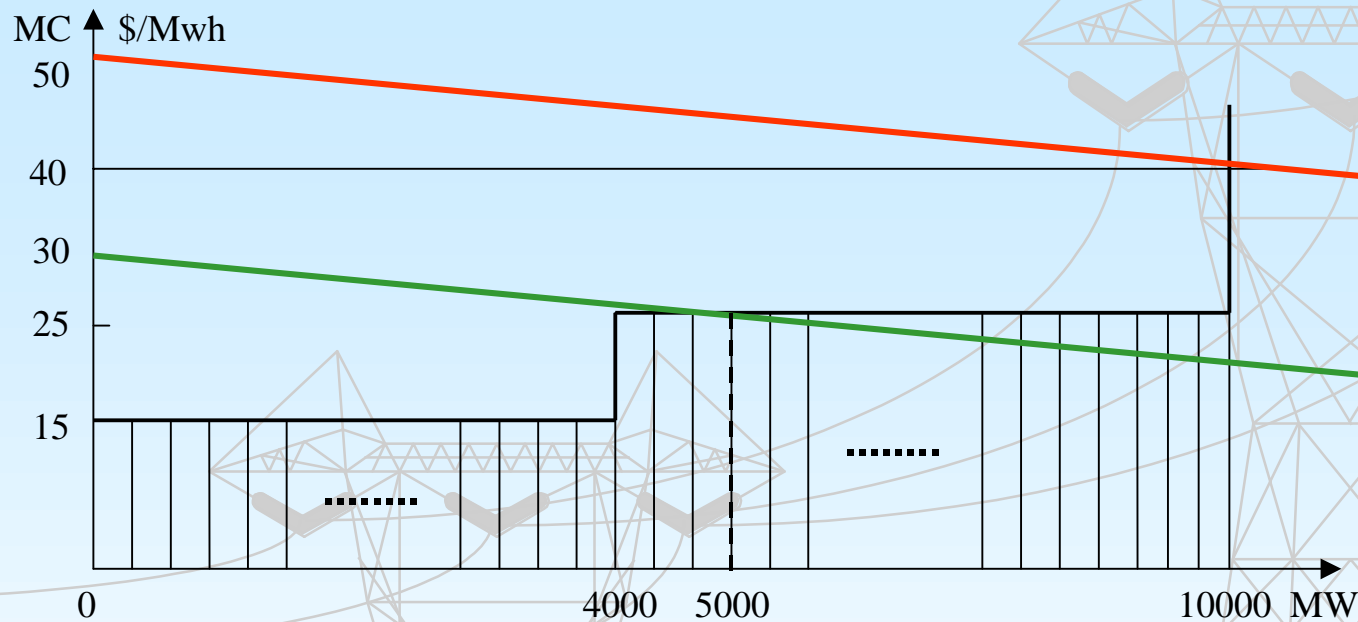
Hrs./Month

$P=30-Q/1000$

$P=50-Q/1000$

(This example is due to Severin Bornstein)

Example of Long Run Equilibrium in Energy Only Markets (cont'd)



- Peak price: \$40/MWh

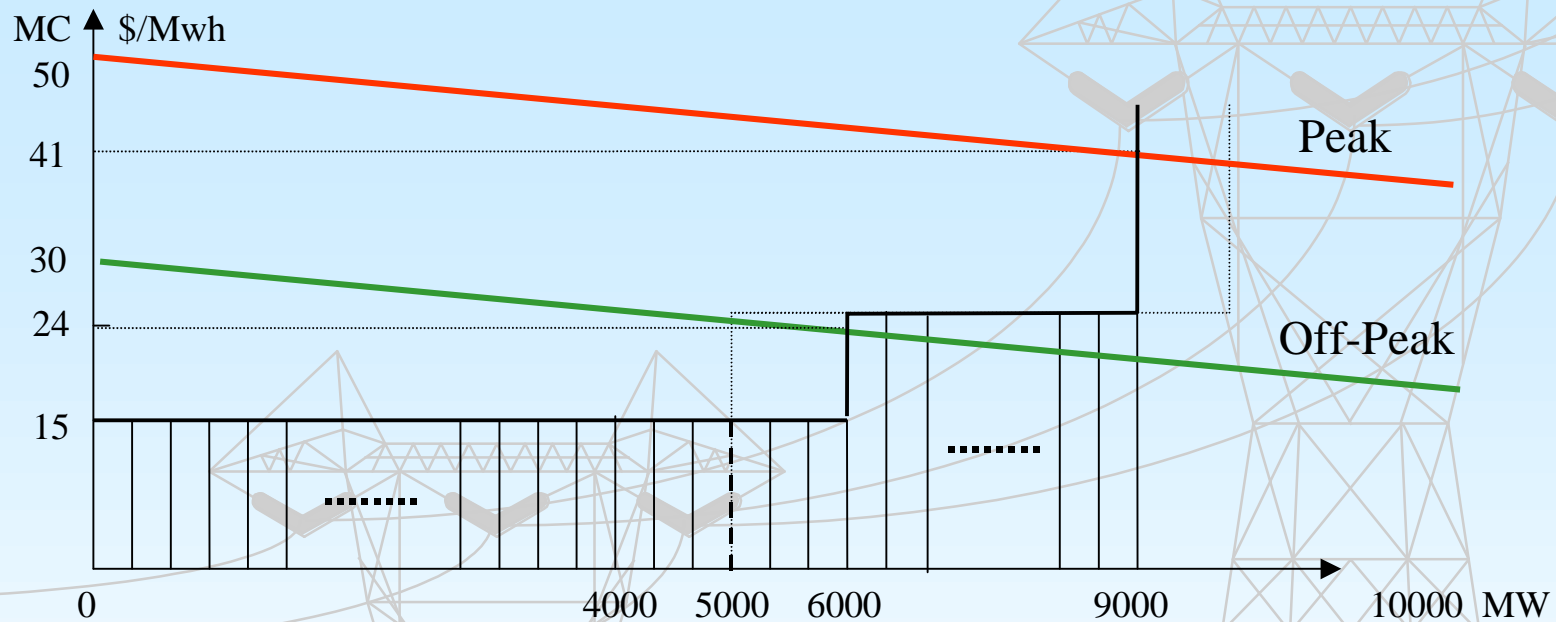
Off-Peak price: \$25/MWh

Fixed cost recovery:

- G1: $80 * [(40-15) * 300 + (25-15) * 420] - 926,400 = \$9,600/\text{Month}$ (excess profit)

- G2: $60 * (40-25) * 300 - 288,000 = (\$18,000/\text{Month})$ (deficit)

Example of Long Run Equilibrium in Energy Only Markets (cont'd)



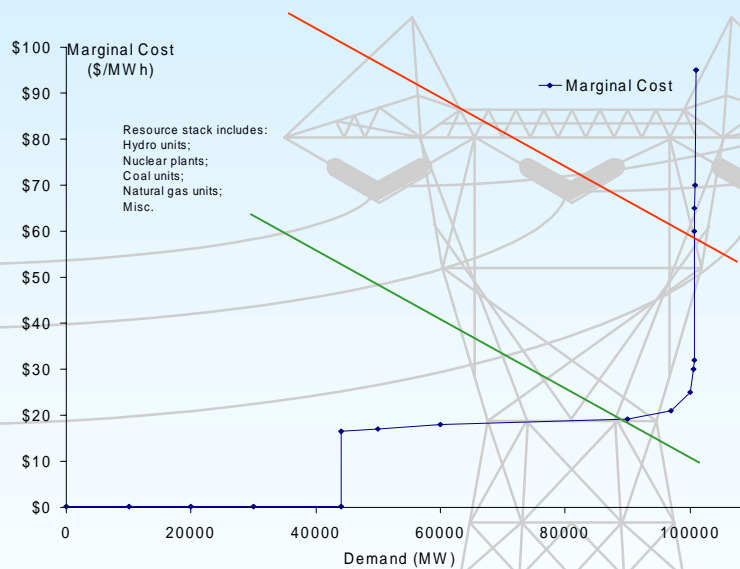
Long Run Equilibrium:

- Entry of 2000MW G1 capacity, Exit of 3000MW G2 capacity
- Peak price \$41/MWh Off-Peak price \$24/MWh
- G1: $\$926,400 = 80 * [(41-15)*300 + (24-15)*420]$ G2: $\$288,000 = 60 * (41-25) * 420$

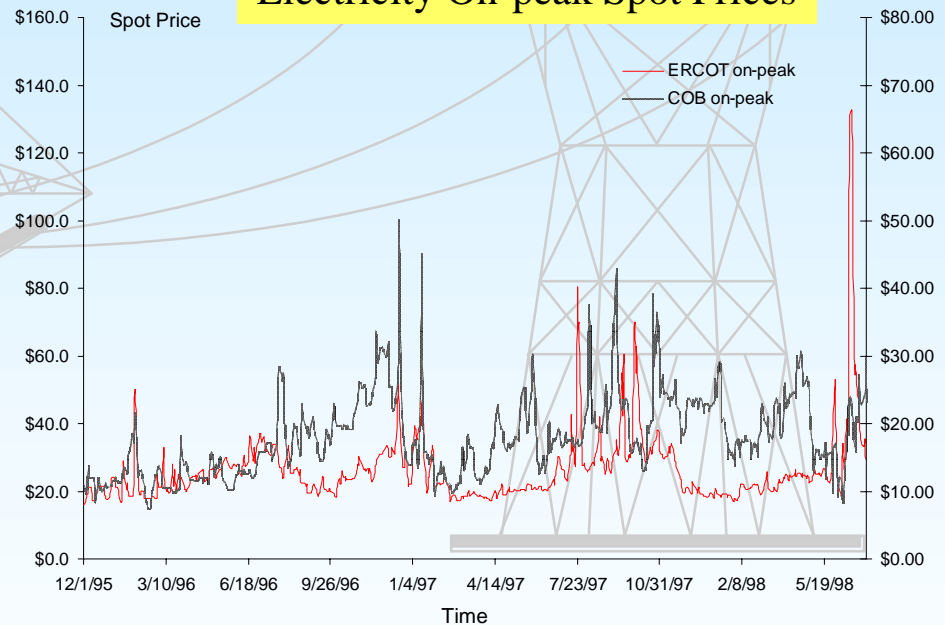
Supply and Demand Uncertainty Cause High Price Volatility in Energy Only Price Systems

- Price volatility is an inherent aspect of electricity due to its nonstorability and the steep supply curve.

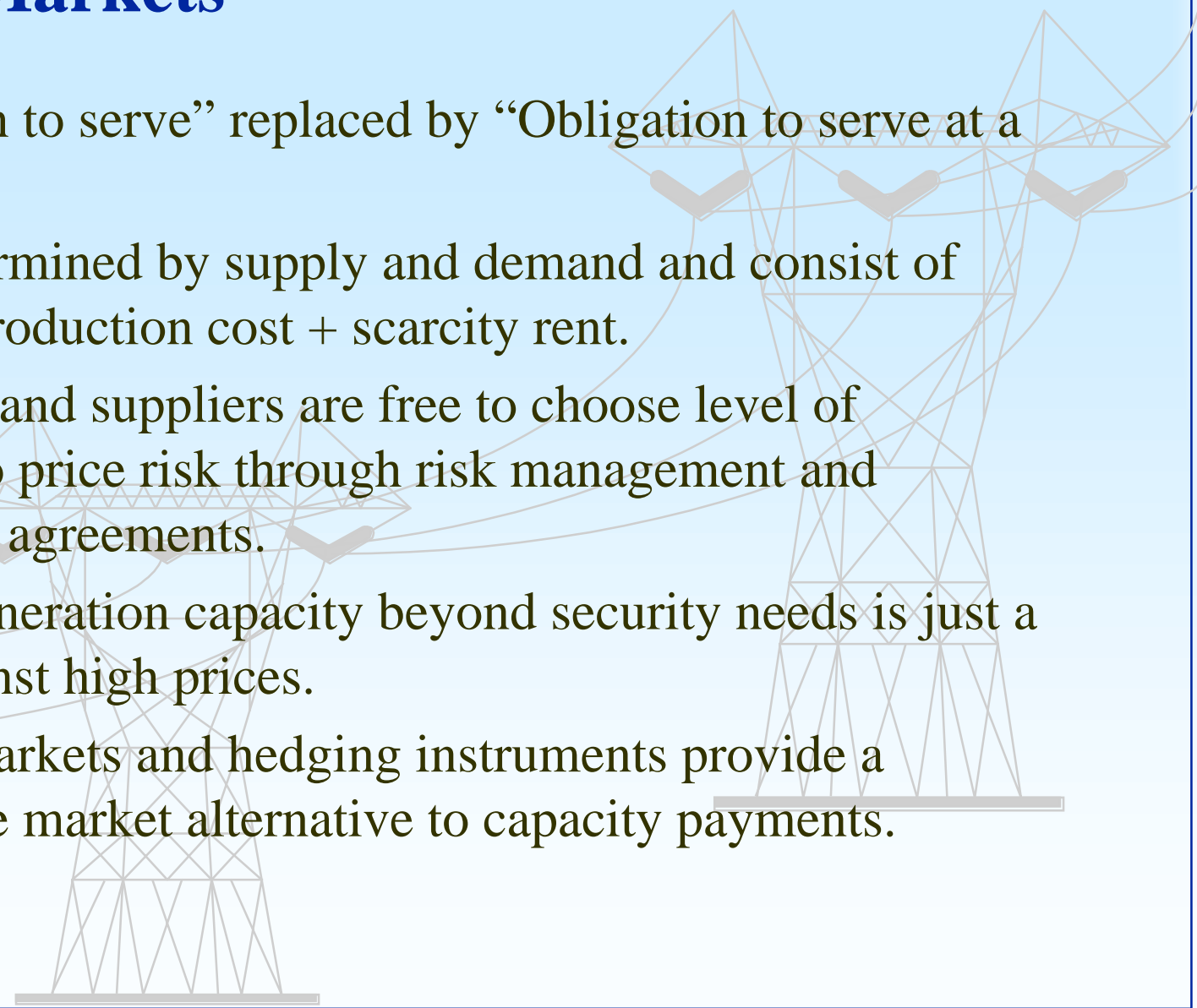
WSCC Generation Resource Stack



Electricity On-peak Spot Prices



Some Fundamental Aspects of Competitive Electricity Markets

- “Obligation to serve” replaced by “Obligation to serve at a price”.
 - Prices determined by supply and demand and consist of marginal production cost + scarcity rent.
 - Customers and suppliers are free to choose level of exposure to price risk through risk management and contractual agreements.
 - Reserve generation capacity beyond security needs is just a hedge against high prices.
 - Forward markets and hedging instruments provide a competitive market alternative to capacity payments.
- 
- A faint, stylized background image of high-voltage power lines and transmission towers, rendered in a light brown or tan color, set against a light blue gradient background. The towers are lattice-structured and the lines are thin and crisscrossing, creating a complex geometric pattern.

How it Can Be Done

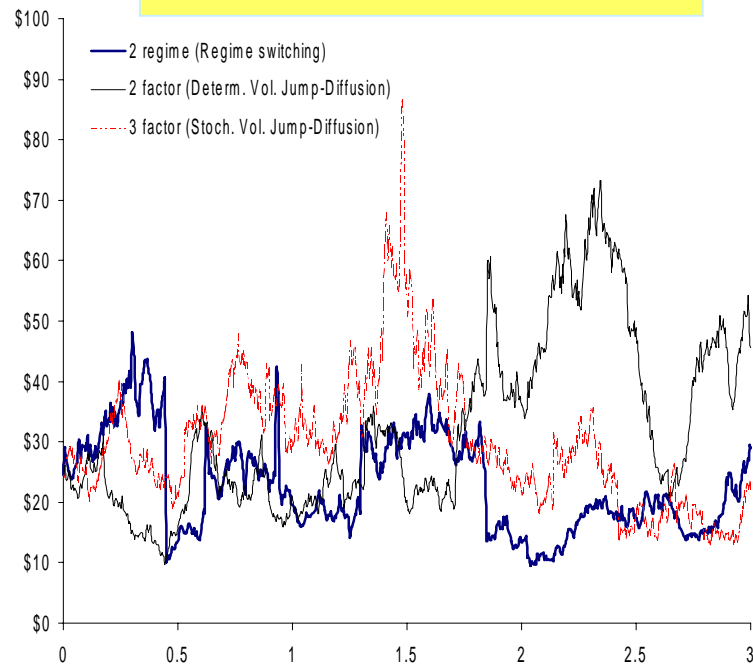
- Buyers decide how much they want to pay for capacity according to the price risk they are willing to assume or price level at which they are willing to be curtailed (buyer is responsible for providing curtailment technology or demonstrating ability to incur financial risk).
- Generators diversify investment risk through forward supply contracts that systematically link capacity payments to an obligation to supply energy at a pre-specified “strike price” (generator is liable to supply contracted energy or compensate the buyer at VOLL).
- Generators that do not receive capacity payments (uncontracted) are entitled to sell their energy at free market prices which can go as high as VOLL.
- Generation gets built if market value of capacity (as reflected by contract markets) exceeds cost of new generation.

How it Can Be Done (con'd)

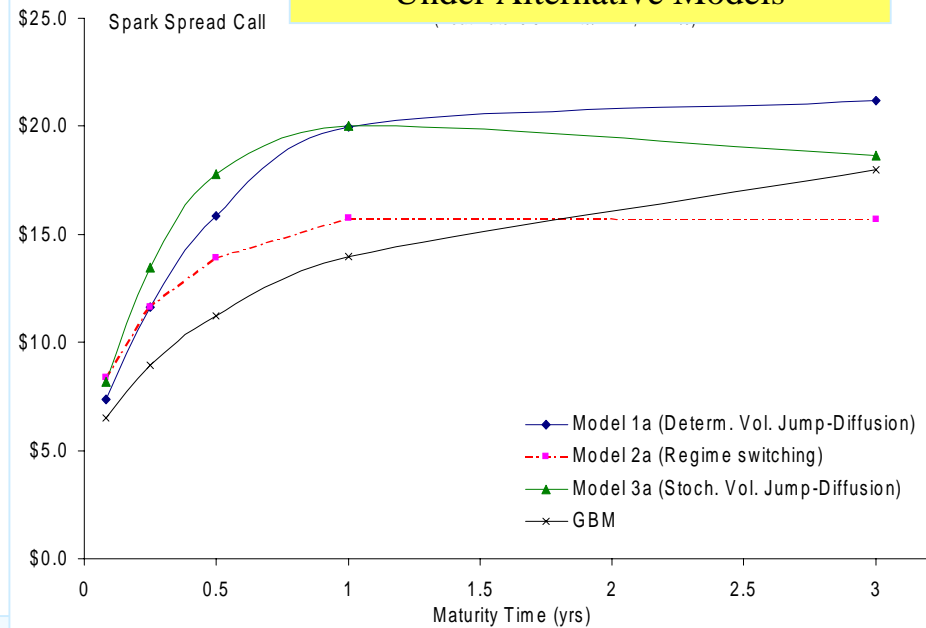
- Demand can participate in mitigation of price risk by avoiding capacity payments (not contracting) and subjecting their load to curtailment (or self-curtailing) during high price periods.
- VOLL can be set administratively or replaced by demand side response to price signals. VOLL serves both as a price cap for uncontracted energy and as a penalty for contracted but not delivered energy.
- The role of regulatory agencies is reduced to ensuring that load serving entities and generators have the resources (financial or physical) to meet their obligations. Public risk exposure may be regulated by imposing requirement for forward contracting on load serving entities.
- Theoretical probabilistic models for calculating LLOP are replaced by stochastic price models underlying the pricing of forward contracts but pricing is left to the market participants.

Alternative Price Behavior Models Produce Different Capacity Values

Alternative Price Behavior Models



Value of Spark-Spread Call Options Under Alternative Models



The role of models is to forecast prices but not to set them.

The market figures the right price.

Conclusions

- Capacity Payments undermine the potential gains of deregulation by leading to over-investment, wrong technology choices, and foreclosure of demand-side options.
- Regulation should focus on facilitating decentralization, trading, customer choice and demand side responses (foster metering communication and EC technologies)
- The role of capacity payments in ensuring adequacy of supply can be fulfilled by risk management approaches and hedging instruments that permit diverse choices and promote demand side participation. The value of capacity as a hedge for price risk should be determined by the market.
- If capacity payment are intended to correct failures of capital markets then regulatory intervention should address directly the availability and cost of long-term financing for capacity expansion secured by short-term contracts (e.g., through loan guarantees) and focus on promoting market confidence and rules that facilitate liquid markets for energy futures and other risk management instruments.