Risk Management in Electricity Market Design

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Outline

• Introduction
• Basic questions of risk management
• Effects of restructuring on regulatory compact
• How to restructure utility service obligation
• Conclusion
Attributes of Electricity and Incomplete Markets

• Electricity is not storable
  – Demand and supply must be balanced in real-time
  – System reliability is a **public good**

• Externality is prevalent throughout the system
  – Excessive peak demand reduces system reliability
  – Transmission congestion/losses due to loop flows
  – Environmental impacts

• The network is governed by **non-convexity**
  – Economies of scale/scope
  – Shift factors vary with power flow patterns
  – Fixed unit commitment costs, minimum run

• Commercial exchange is handicapped by the limited **availability of**
  real-time transaction **information**
Two Types of Risk

• Price risk: private risk ⇔ investment adequacy
  – Spot markets
  – Forward/futures/options markets
  – Long-term contracts

• Quantity risk: public risk ⇔ system reliability
  – Generation scarcity ⇒ market power & unreliable system operation
  – Transmission scarcity ⇒ fragmented system & local market power
Restructuring Raises Basic Questions of Risk Management

• Vertical integration provides insurance along supply chain
  – Vertical integration buffered price volatility
  – Retail rate regulation smoothed effects on customers
  – ROR regulation insured utilities and their investors

• Vertical unbundling results in redistribution of risks
  – Utility becomes a financial intermediary using long-term contracts and other financial instruments
  – Default service obligation needs to be restructured
  – Develop price-responsive demand so that some risk can be shifted to retail customers
Regulatory Compact

- Franchise control
- Rate making
- Utility service obligation

Just and reasonable price
Fair rate of return
Adequate and reliable supply
Obligation to serve
More on Regulatory Compact

• Franchise control - The state commission controls the entry of the utility’s competitors and the exit of its customers

• Rate making - The commission authorizes rates that allow the utility a reasonable opportunity to earn a fair rate of return on investment that reflects the cost of capital financed in debt and equity markets

• Utility Service Obligation (USO)
  – The utility must comply with regulatory accounting procedures for cost disclosure and price regulation
  – The utility must meet service quality standards and invest in transmission and access services to all customers within its service territory
  – The utility must operate efficiently and make only prudent investments as determined by the regulatory commission
Change Began with PURPA Which Gives the IPP’s an Option to Enter

*PURPA: Public Utility Regulatory Policy Act, 1978*
Restructuring Gives Large Customers the Option to Exit

- Generator
- Wholesale Markets
- Utility
- Wholesale Customer
- Retail Customer

- Long-term contracts
- Direct access
- Utility service obligation
- Regulated rates
Restructuring Causes Utility’s Cost and Risk to Rise

• Large base-load customers find bilateral contracts more attractive
• The utility is susceptible to adverse selection with a deteriorating load shape
• The cost of service will rise, causing an increase in the number of rate hearings
• Long-term contracts will receive close scrutiny in regulatory review with unpredictable results
• This results in an increase in the business risk and the cost of capital
• The cost of service will increase still further
Restructuring Utility Service Obligation is Key to a Sustainable Regulatory Contract

• Differentiated service pricing is essential to mitigate the problem of adverse selection

• Price-responsive demand is imperative to allow some risk to be shifted to retail customers

• Key elements of USO restructuring
  – Differentiation of load shape
  – Risk sharing of reliability
Load Shape Pricing Mitigates the Adverse Selection Problem

- Rate = Min [Fixed capital charge + Variable charge*Load factor]
- Payment = Rate*Maximum contracted load
A Consumer Choice Model for Spot Purchase and Contract

- Consumers decide on spot purchase \( q_s \) and contract \( q_c \)
- Spot price at time \( t \) is \( p_s(t) \); price schedule for contract is \( (k, c) \)
- The capital cost for generation in spot market is \( k_s \)

\[
\begin{align*}
\text{Max} & \int_0^T U_t(q_s(t) + q_c(t)) - p_s(t)q_s(t)dt - k\hat{q}_c - c\int_0^T q_c(t)dt \\
q_c(t) & \leq \hat{q}_c, q_c(t) \geq 0, q_s(t) \geq 0 \\
k\hat{q}_c + c\int_0^T q_c(t)dt = \int_0^T p_s(t)q_c(t)dt \iff k = \int_0^T [p_s(t) - c]^+ dt = k_s
\end{align*}
\]
Impacts of Competitive Wholesale Markets on Retail Business

- Competing with direct access and bilateral contracting, the utility need to win back base-load customers
- This can be done through differentiation of retail rates by load shape
- Risk averse consumers can subscribe hedging services
- The utility could collect a premium for bearing the risk of the price variation in the spot market
- When the cost-of-capital for production in spot market is greater than the cost-of-capital for contract, the utility will compete in the financial intermediary service
Theoretical Relationship Between Wholesale and Retail Rates

- Retail rate = Expected spot price for each category of service + risk premium
- The first component can be computed using a price duration curve

![Diagram showing spot price, fixed charge, variable charge, and price duration curve.]

Spot price

Fixed charge

Variable charge

Price duration curve

Fraction of time

0

T₁
Sharing Reliability Risk Implies Non-firm Default Service

- Under restructuring, the concept of default service becomes ambiguous
- The obligation to serve at any spot price is unsustainable
- Continued ambiguity will deter demand response

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Equilibrium Relationship Between Wholesale and Retail Rates

- Retail rate = \( \int \mathbb{E}\{ p(t) \mid c \leq p(t) \leq \text{trigger}, T_0 \leq t \leq T_1 \} \, dt + \text{risk premium} \)
Risk Sharing Fosters Demand Response and Competitive Markets

- Risk sharing provides incentives for demand response and reliability differentiation
- This will result in improved system reliability and lowered spot prices
- The retail services will improve with lower prices and higher quality
Conclusion

• Restructuring poses major risk management challenges in power market design
• Vertical unbundling exposes the regulatory compact to the adverse selection problem
• Service differentiation and risk sharing are essential for new regulatory compact
• Effective risk management fosters demand response and competitive markets