Price Responsiveness of the Deregulated Electricity Market in Singapore

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Market reforms in the electricity industry

- Drivers for the reform
  - Perceived failure of cost-of-service regulation
  - New economically viable generation technology in a small scale
- Expectation from the reform
  - Lower prices
  - More choices
  - Reliable services
  - Advancement of technology
  - Timely investment
- The likely gains may not be as great as the proponents have previously argued

Efficiency in the electricity market

- Production Efficiency
  - The right amount of goods using the right mix of inputs, so as to minimize costs of production
- Consumption Efficiency
  - The right amount of budget on the different goods available, so as to maximize utility
- Allocation Efficiency
  - The right goods go to the right consumer
- There could be efficiency gains from deregulation
  - Singapore started electricity deregulation in 1995
  - Does a move from regulated tariffs to unregulated prices increase consumption efficiency?

Deregulation of the electricity industry in Singapore

- Separation of the industry by ownership
  - Introducing competition into the sectors
    - Generation
    - Wholesale and retail electricity market
  - Retaining monopoly structure
    - Transmission & Distribution
  - Market support services
    - For metering, consumer transfers between retailers, sale of electricity to non-contestable consumers, provision of other services
    - Geared to facilitate competition in the electricity retail market
- New independent system operator and market operator
    - Separation of the system and market operations

New Electricity Market of Singapore (NEMS)

- Singapore Electricity Pool (SEP)
  - A day-ahead market
  - From 1998 to June 2001
    - There was a sole purchaser (Power Supply Ltd)
  - From July 2001 to December 2002
    - Introduction of contestable customers whose power requirement is greater than 2 MW
- NEMS starts on January 01, 2003
  - A mandatory pool
  - A spot market for electricity and reserves operated by the EMC (market operator)

Market structure of the NEMS

- Energy Market Company (EMC): Market operator
- Horizontal link among Generations-Wholesale market-Retailers-Consumers
- Wholesale market
  - Consists of electricity spot market and spinning reserve market
  - Generators provide electricity and reserved capacity to Wholesale market
  - Retailers purchase electricity from the electricity spot market while they provide interruptible loads to the spinning reserve market
  - Consumers get electricity via retailers
- Retailers could get electricity directly from generation companies via bilateral contracts
- MSSL supports retailers, consumers, and spinning reserve market

Players in the NEMS

- Energy Market Authority (EMA): Industry regulator
- Energy Market Company (EMC): Wholesale market operator
- SP PowerAssets and SP PowerGrid: Owner and operator of T&D
- Market Support Services Licensee: SP Services
- 7 Generators (5 in operation): 3 largest generators have about 90% of the total installed generation capacity
- 6 Retailers (5 in operation)
- Consumers: contestable and non-contestable based on their average electricity consumption

Contestable consumers

- Contestable consumers could purchase electricity
  - From the retailers
  - From the wholesale market via the Market Support Services Licensee (MSSL)
  - By trading directly in the market

- Progress in liberalization of the electricity retail market
  - About 250 large consumers have become contestable since July 2001
    - Covers 40% of the total electricity demand
  - From June 2003, another 5,000 non-domestic consumers have become contestable in batches
  - As of December 21, 2003, another 5,000 consumers have became contestable (average monthly electricity consumption > 10MWh)
    - Covers 75% of the total electricity demand

Vesting contracts

- Vesting contracts are implemented from January 2004
  - A contractual obligation of the generation companies to produce a specified quantity of electricity
  - 65% of total demand are vested (price-capped)
    - Non-contestable consumers are fully covered by vesting contracts (30%)
    - 35% of the vested quantity will be used to meet contestable demand
  - The price for the remaining 35% is determined by competition in the wholesale market
  - The vested quantity constitutes 30% of the installed generation capacity
  - The amount vested will gradually diminish and be abolished

Power generation and electricity consumption

- Power generation capacity
  - Authorized capacity: 11,490 MW
  - Installed capacity: 8,919 MW (June 2003)
  - Peak demand
    - 5,139 MW
    - Peak Reserve Ratio > 40% (5,139/8,919)
- Total electricity sales in 2002
  - 31,089.3 GWh (4.8% increase over 2001)
- Electricity consumption profile
  - Little seasonal variation
  - Substantial variation from weekdays to Saturdays and Sundays
  - Load profile over a day is very static
  - Consumption grows at a higher rate

Consumption efficiency

- A price that varies throughout the day would persuade the consumer to delay or reduce consumption when the good is expensive
- A tariff that changes only once every few months does not encourage the consumer to cut back on electricity use during peak hours when it is the priced highest
  - Higher price elasticity of electricity demand for contestable consumers than that for non-contestable consumers
- The NEMS would yield greater consumption efficiency

Data

- Contestable consumers (CC)
  - Half-hourly price and quantity data for contestable consumers
    - From July 01, 2001 to October 31, 2002 (Singapore Electricity Pool)
    - From January 01, 2003 to February 09, 2004 (NEMS)
- Non-contestable consumers
  - Quantity data for non-contestable consumers (NCC)
    - derived by subtracting that of contestable customers from the total demand
  - Price data for the NCC: tariff rates

Two-Stage-Least-Squares Regression

- A log-linear model

$$Log(Q) = A_1 \log(P_x) + A_2 \log(Q(-1)) + A_3 \log(Q(-2)) + A_4 t + C + \varepsilon,$$

where Q is the average quantity demanded, P_x is the electricity price
C is the constant term, t is the trend variable, and ε is the error term

- Seasonal Autoregressive (SAR) Errors

$$(1 - \rho_1 L - \rho_2 L^2)(1 - \varphi L^4) e_t = u_t,$$

where L is the lag operator, ρ and φ are
the autoregressive and seasonal autoregressive
coefficients, and u is the error term

Regression results (SEP)

- Contestable consumers

$$\log(Q) = -0.0009\log(P_x) + 1.125\log(Q(-1)) - 0.142\log(Q(-2)) + 0.02\log(Q(-336))$$
$$\text{(-6.16)}^{***} \qquad (57.46)^{***} \qquad \text{(-7.19)}^{***} \qquad (18.02)^{***}$$

- Non-contestable consumers

$$\log(Q) = +0.00019\log(P_x) + 0.51\log(Q(-1)) + 0.44\log(Q(-2)) - 0.38$$
$$(0.84) \qquad (43.57)^{***} \qquad (39.05)^{***} \qquad \text{(-19.02)}^{***}$$

Regression results (NEMS)

- Contestable consumers

$$\log(Q) = -0.0016\log(P_x) + 0.6334\log(Q(-1)) - 0.3625\log(Q(-2)) - 0.0021\log(Q(-336))$$
$$\text{(-6.16)}^{***} \qquad (57.46)^{***} \qquad \text{(-7.19)}^{***} \qquad (18.02)^{***}$$

- Non-contestable consumers (Price)

$$\log(Q) = -0.0018\log(P_x) + 0.697\log(Q(-1)) + 0.211\log(Q(-2)) + 0.033\log(Q(-48)) + 0.0575\log(Q(-336))$$
$$\text{(-1.04)} \qquad (28.07)^{***} \qquad (9.47)^{***} \qquad (9.57)^{***} \qquad (13.81)^{***}$$

- Non-contestable consumers (Tariff)

$$\log(Q) = -0.09\log(TAR) + 0.689\log(Q(-1)) + 0.211\log(Q(-2)) + 0.019\log(Q(-48)) + 0.044\log(Q(-336))$$
$$\text{(-8.71)}^{***} \qquad (27.25)^{***} \qquad (9.36)^{***} \qquad (5.14)^{***} \qquad (10.29)^{***}$$

Price responsiveness

- Contestable consumers
  - Inelastic (-0.0016): a little responsiveness
- Non contestable consumers
  - Demand appears not to depend on the price of electricity, but tariffs (-0.09)
- Implications of a little or no price-responsiveness
  - Price changes may not induce greater consumption changes
  - Savings from the reform would come mainly from the cost reductions in power production
  - The reform may not substantially reduce deadweight loss
  - However, moving from regulation to deregulation would improve the consumption efficiency

Price-Cost Markups

- Price data
  - Uniform Singapore Electricity Price (USEP)
  - January 01, 2003 – June 25 2004
  - Short-Run Marginal Cost (SRMC) of Combined Cycle Gas Turbines (CCGP) - the most efficiently configured power plant
  - Long-Run Marginal Cost (LRMC)

- (Price – Marginal Cost)/ Price
  - Entire periods: SRMC (0.4150) LRMC (0.0915)
  - 1/01/03 – 12/31/03: SRMC (0.4467) LRMC (0.1250)
  - 1/01/04 – 6/25/04: SRMC (0.3455) LRMC (0.0185)

Final remarks

- Deregulation in Singapore electricity market
  - Steady and phase by phase with vesting contracts
- Efficiency gains
  - Deregulation would improve consumption efficiency by making non-contestable consumers more price-responsive
  - Whether the purported efficiency gains are realized is to be seen as the liberalization proceeds
- Future study
  - Examine whether the NEMS leads to marginal cost pricing, in other words whether it produces prices that are close to the marginal costs under least cost power dispatch