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 \( \varepsilon \) 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, \( \rho \) and \( \varphi \) are the autoregressive and seasonal autoregressive coefficients, and \( u \) is the error term.
Regression results (SEP)

- **Contestable consumers**
  \[ \log(Q) = -0.0009 \log(P_x) + 1.125 \log(Q(-1)) - 0.142 \log(Q(-2)) + 0.02 \log(Q(-336)) \]
  \[ \begin{align*}
  (-6.16)^{***} & \quad (57.46)^{***} & \quad (-7.19)^{***} & \quad (18.02)^{***}
  \end{align*} \]

- **Non-contestable consumers**
  \[ \log(Q) = +0.00019 \log(P_x) + 0.51 \log(Q(-1)) + 0.44 \log(Q(-2)) - 0.38 \]
  \[ \begin{align*}
  (0.84) & \quad (43.57)^{***} & \quad (39.05)^{***} & \quad (-19.02)^{***}
  \end{align*} \]
Regression results (NEMS)

• Contestable consumers

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

• Non-contestable consumers (Price)

\[ \log(Q) = -0.0018 \log(P_x) + 0.697 \log(Q(-1)) + 0.2111 \log(Q(-2)) + 0.033 \log(Q(-48)) + 0.0575 \log(Q(-336)) \]
\[ (-1.04) \quad (28.07)^{***} \quad (9.47)^{***} \quad (9.57)^{***} \quad (13.81)^{***} \]

• Non-contestable consumers (Tariff)

\[ \log(Q) = -0.09 \log(TAR) + 0.6891 \log(Q(-1)) + 0.2111 \log(Q(-2)) + 0.019 \log(Q(-48)) + 0.044 \log(Q(-336)) \]
\[ (-8.71)^{***} \quad (27.25)^{***} \quad (9.36)^{***} \quad (5.14)^{***} \quad (10.29)^{***} \]
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)
  – 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