Abstract

The generation market of the New Electricity Market of Singapore (NEMS) appears highly concentrated by a four-firm concentration ratio or the Herfindahl-Hirschman Index. However, other measures of market power present that the NEMS is working at close to a competitive market. First, there seems to be a number of effective competitors in the market. Second, Supply Margin Assessment confirms that there is no pivotal supplier in the generation market of the NEMS and the Residual Supply Index also confirms that the market is competitive though there are some possibilities in which the largest generator or a few large generators jointly could still have market power. Third, the Lerner Index of the NEMS shows that the generation market is fairly competitive and the Lerner Index adjusted with an industry level price elasticity of demand implies that there has not been much exercise of market power.

Vesting contracts – a contractual obligation of a specified quantity of electricity supply to the market – have been implemented in the NEMS since 2004 and are proven as a strong and effective tool to mitigate market power, provided that there has been market power in the NEMS. The vesting contracts are considered the force behind the lowering in the average Uniform Singapore Electricity Price and the Lerner Index in 2004. Along with the lower average prices, the new electricity market structure is believed to deliver economic gains in production of electricity. The new market structure also suggests that price-responsiveness of consumers in the NEMS would increase as the market moves to the full competition mode.

I. Introduction

When a vertically-integrated electricity industry is restructured into generation, transmission and distribution (T&D), and wholesale in a deregulated electricity market, the unbundling encourages competition among different players, remove regulatory haze, and brings efficiency gains and consumer savings. A deregulated market makes an entry to the market easy and brings more players into the market. Hence, competition in the market is encouraged, and more players can react to outside shocks more smoothly and flexibly. Through the electricity market reform, competition is believed to bring forth higher efficiency, lower and stable prices, reliable services and even timely investment. By reducing excess capacity and planning systematically, bringing more players could achieve efficiency gains. But the outcomes of the deregulation in electricity markets are mixed (Arocena, Contin and Huerta, 2002; Besant-Jones and Tenenbaum, 2001; Brennan, Palmer and Martinez 2002; Cabral, 2002; Clark, 2001; Joskow, 2001; Sioshansi, 2002; Woo, Lloyd and Tishler, 2003).

As the new electricity markets such as Australia, England and Wales, Ontario, Norway and California show, some functional components of the industry could be deregulated (Steiner, 2000). Of the different functional components, T&D is conventionally regarded as a natural monopoly because competition would result in the duplication of networks. Thus with deregulation, T&D remains a regulated monopoly and access to its network (by generation companies and suppliers) is rendered mandatory by Third Party Access (TPA) legislation or

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rules. The retail sectors per se are not considered natural monopolies because just like any other retailer, electricity retailers face increasing costs as they expand in size. While for generators, with a market for energy trading, the generators no longer need to be big to handle the problems of peak load and fluctuating demand.

Through deregulating electricity markets, economic efficiency improvement could be realized in various ways. First, producers should produce the right amount of goods using the right mix of inputs, so as to minimise costs (production-efficiency). Second, consumers spend the right amount of their budget on the different goods available, so as to maximise utility (consumption-efficiency). Lastly, the right goods go to the right consumer i.e. the one who is willing and able to pay (allocative-efficiency). With these efficiency measures, it could be shown that regulated markets tend to suffer from inefficiencies and therefore, there are gains from deregulation. For example, generation and retail sectors are not natural monopolies and regulation will only distort the workings of market forces. With the removal of this regulatory haze, the market participants will be able to carry out investment and production decisions efficiently (Ballonoff, 1997).

The liberalization of electricity industry in Singapore has begun in 1995 when Singapore Power, then a wholly government-owned vertically integrated monopoly, took electricity and piped gas functions from the Public Utilities Board (PUB). Singapore Power Ltd (SP) is the resultant corporate entity as a result of this spin-off. Although a corporate entity, Singapore Power Ltd is still wholly government-owned as it is held under the government holding company - Temasek Holdings. SP was responsible for the generation, transmission and distribution, wholesale and retail of electricity. PUB subsequently fulfilled a regulatory function with regards to the energy sector.

The industry had gone through a full deregulation in generation sector and a day-ahead market for electricity trading under Singapore Electricity Pool (SEP) was launched in 1998. The SEP was a primitive step or forerunner for competitive electricity trading. SP PowerGrid, a wholly owned subsidiary of Singapore Power, is the Grid owner and also the system operator for the SEP.1 Before July 2001, Singapore Power (SP) or more specifically, its then retail subsidiary, SP Services was the sole purchaser in the SEP.2 In April 2001, SP divested its two power generation subsidiaries, PowerSeraya and PowerSenoko to its parent company, Temasek Holdings. The PUB became solely a water authority when the government established a new statutory board - the Energy Market Authority (EMA) to regulate the energy industries. A new company - the Energy Market Company Pte Ltd (EMC) was set up as a joint venture between EMA and M-co (the Marketplace Company) Pte Ltd to implement and operate the upcoming wholesale electricity market. However, electrical output is still transmitted via the transmission and distribution (T&D) network owned and operated by SP PowerGrid, and T&D prices remain regulated.

At this stage of partial deregulation in 2001, consumers were deemed “contestable” if they had maximum power requirements exceeding 2MW and were able to purchase power from either retailers or SP Services, the retail arm of Singapore Power. SP Services was also the designated Public Electricity Supplier (PES) and retails electricity to the non-contestable customers. Thus, at this stage of deregulation, the generation sector was already fully open to competition while that for the retail sector was partially so. The day-ahead market for electricity trading under SEP has lasted until December 2002.

The New Electricity Market of Singapore (NEMS) began on January 1st 2003. The NEMS consists of seven players: an industry regulator, a market operator, a grid owner-cum-operator, a market support services licensee, generators (seven generation licensees), retailers (six retail licensees) and two types of consumers (contestable and non-contestable). The NEMS is horizontally connected under the Energy Market Authority (EMA) as an industry regulator and system operator, and the Energy Market Company (EMC) as a market operator.
Generation is now open to full competition while wholesale and retail markets are partially open. Generators supply power to consumers through a wholesale market operator, retailers or market support services licensees (MSSLs) while the generated electricity is conveyed through the transmission and distribution network owned by SP PowerAssets (SPPA) and SP PowerGrid (SPPG) (formerly known as PowerGrid).

The electricity retail market has been opened up gradually. Since July 2001, consumers with maximum power requirements exceeding 2MW are able to purchase electricity from retailers of their choice under the day-ahead market of SEP. The retail market is being further opened up and about 250 consumers have become contestable since July 2001, representing about 40 percent of the total electricity demand. Since June 2003, 5,000 non-domestic consumers with average monthly electricity consumption of more than 20MWh have become contestable. Another 5,000 consumers with average monthly consumption of 10MWh have become contestable at the end of 2003 and the total contestable market covers 75 percent of the total electricity demand as well as almost all of non-domestic consumers. The further deregulation in retail market has not been made since then.

The main governing principle of the NEMS is the separation of competitive activities like electricity generation and trade in the market, and monopolistic market support activities such as transmission, metering, consumer transfers between retailers, and other facilitation services. No crossover is allowed between the competitive activities and the monopolistic ones. Hence, there is a fully-contestable market for generation, wholesale and retail, and regulated grid operations. Another major governing principle is a gradual transition of retail markets to full competitive electricity markets with imposing temporary restrictions on market power such as implementation of vesting contracts. The vesting contracts are basically designed to protect non-contestable consumers from being exposed to excessive price volatility during the transition to full competition.

As three largest generators in Singapore – PowerSeraya, Senoko Power and Tuas Power – hold about 90 percent of the total installed electricity generation capacity, market power of the generation companies was checked by a mandatory price cap set for 100 percent of the total demand in 2003 and the generation companies were not allowed to cause prices to rise beyond the price cap. However, they could use their market power to keep electricity prices to the allowed price cap. From January 1, 2004, as a way of controlling potential abuse in market power, vesting contracts have been imposed on 65 percent of total demand. The vesting contracts impose a contractual obligation on the generation companies so that they have to produce a specified quantity of electricity. The effect of the vesting contracts is to cap the price of this 65 percent of total demand and the price for the remaining 35 percent is determined by competition in the wholesale market. With the previous price caps and current vesting contracts in place, we can assume that the market price is reflective of true underlying production conditions.

The regulatory framework of the NEMS is subject to revision as the market evolves to full competition and is also contingent on future developments in the market such as concentration of market power, congestion in transmission or mismatch in demand and supply. The performance of the NEMS in the initial period of its implementation is solid as stated by the Chairman of the EMA in an annual report of the fiscal year 2003/04 that the NEMS is competitive and robust in nature and has helped consumers through lowering electricity tariffs resulting from efficiency gains in generation companies and a transmission company, and cost competitiveness from performance benchmarking of the transmission company. In addition, the vesting contracts are believed to help the wholesale electricity prices fall from S$93/MWh in 2003 to about S$73/MWh in the first six months of 2004. However, still some generating companies cast doubts on vesting contracts claiming that vesting would result in “unnecessary exposure and additional payments to customers.” After investigating such claims, the Energy Market Authority reaffirms that “vesting is intended to
control market power and protect customers by ensuring that the settlement price at the pool is a competitive one.”

Upon noticing a seemingly contradicting evaluation of the new electricity market structure and its performance, this study examines the efficiency of the new electricity market structure in Singapore in relation with competition and efficiency. The focus of this study is to identify the possible source(s) of efficiency gains and derive the quantitative estimate of such gains using a multi-pronged approach. The rest of this study is organized as follows. Theoretical aspects of efficiency in a deregulated electricity market are briefly discussed in section II. Section III examines the extent of competition in the NEMS by various measures of market power. Section IV evaluates how vesting contracts affect competition and efficiency in the NEMS. The impact of vesting contracts on market power and possible economic gains from new market structure are also analyzed in section IV. Section V concludes this study.

II. Efficiency in a Deregulated Electricity Market

The marginal cost pricing, where price is equal to marginal cost, is one of the cornerstones of economic efficiency. However, the practice of the condition in electricity generation has been deviated from the optimal one since a generation industry is considered to be a natural monopoly. Hence inefficiency arises from a failure to combine resources efficiently in production. To decrease the inefficiency and increase reliability of generation system, regulation has been introduced. Goldberg (1976) sees regulation as a complicated form of contract and an intermediary between consumers and the firm to address problems as unforeseen possible events arose while Tullock (1967) sees regulation as a broker distributing the rents dependant on changes in the political equilibrium.

It has been argued that under traditional forms of regulation, such as rate of return regulation, companies tend to over-invest; this is called the Averch-Johnson effect (Ballonoff, 1997). This is because, under such regulation, the amount of profits allowed is a certain percentage of approved expenditures. Investment costs to expand or improve the facility are definitely approved expenditures, but firms have an incentive to over-invest (i.e. costs outweigh safety or efficiency gains) since this will allow cost inflation which leads to higher profits.

It is also argued that an alternative and better method of regulation, performance based regulation, known as price caps, which takes into account inflation and incorporates performance standards for areas such as productivity, availability, quality and reliability, may not distort investment decisions. This type of regulation could be applied to T&D sector (Tishler, Woo and Lloyd, 2002). But regulation is not costless and the ensuing transaction costs are of concern. There are four sources of transaction costs: allocative inefficiencies from rate of return regulation, rent seeking, frequent change in distribution rules triggered by lawyers, and resources spent by management to satisfy or convince the regulators (Crew and Kleindorfer, 1986).

A contestable market model was considered little applicable to the natural monopoly since sunk costs are typically significant. But in an unbundled market, especially in generation market the sunk costs were not that significant. Hence, contestable market could work in the unbundled industry (Baumol, Panzar and Willig, 1984). Whether and how an economy achieve a Pareto optimal allocation of factors and goods in a deregulated electricity market could be answered through examining possible efficiency gains in a deregulated electricity market.

When a vertically-integrated electricity industry is deregulated and market forces allowed greater play, such deregulation should bring about efficiency gains in production, consumption, and allocation. Production efficiency implies that producers produce the right amount of goods using the right mix of inputs, so as to minimize costs: the equalization of the
marginal rate of substitution between capital and labor for producers 1 and 2 \((MRS^1_{KL} = MRS^2_{KL})\). Consumption efficiency means that consumers spend the right amount of their budget on the different goods available, so as to maximize utility: the equality between the marginal rate of substitution between two goods (1 and 2) for consumers \(A\) and \(B\) \((MRS^1_{12} = MRS^B_{12})\). Allocation efficiency is that the right goods go to the right consumer, in other words the one who is willing and able to pay: the equalization of the marginal rate of transformation between the two goods and the marginal rate of substitution between the two consumers \((MRT^1_{12} = MRS^2_{12})\).

In a deregulated electricity market, these efficiency measures are expected to increase, and they might be considered benefits of deregulation. Along with the underlying energy efficiency increases, consumer savings could be realized through three different paths. First, under rate of return regulation, costs are prone to increase and so is end-user cost. With deregulation and removal of the regulatory haze, producers do not have incentives to over-invest and inflate costs. Second, with deregulation, monopoly profits would disappear. Finally, competition among suppliers in the spot market would drive down prices in the wholesale market, and competition among suppliers would drive down prices in the retail markets.

Under regulation, prices of electricity are not at their true competitive market levels. As such, consumers are not able to gauge the relative prices with accuracy and this likely result in consumption inefficiency. When the prices are artificially low, consumption decisions are distorted (Anex, 2002). For example, regulated low prices prevent fuel cost increases from being passed on to consumers; and as such, consumers have no incentive to modify their consumption behaviour. Consumption efficiency is examined such that whether a move from regulated tariffs to unregulated prices would increase efficiency, based on the rationale mentioned above. A price that reflects actual cost conditions would facilitate decision making by the consumers. While a tariff, which varies only once every few months, does not encourage the consumer to cut back on electricity use during peak hours (when it is priced highest), a price that varies throughout the day will persuade the consumer to delay or reduce consumption when the good is expensive.

The basic premise being that with a market mechanism, there should be greater allocative efficiency. In the NEMS, contestable consumers have the option of purchasing electricity by direct participation in the market or via retailers. Proceeding along the lines of an auction, the consumer who needs the electricity desperately, e.g. a manufacturing plant which cannot afford any interruptions to its operations will pay for electricity even when it is most expensive and will go to retailers who can fulfil its demand, albeit at a higher price, if necessary.

These efficiency gains and savings could be considered benefits of deregulation in electricity market. However, the likely gains from deregulation may not be as great as the proponents have previously argued (Crew and Schuh, 2002). Deregulation provides new opportunity for rent-seeking when regulation was inaction. Whether abolition of regulation and moving towards deregulation bring workable level of competition, yield efficiency gains and achieve a full competitive or completely unregulated outcome are examined with the New Electricity Market of Singapore in the following sections.

**III. Competition in the New Electricity Market of Singapore**

The authorized electricity generation capacity in Singapore is 11,640MW while the installed capacity is 8,919MW as of December 2003 (and not much change since then) and the system
peak demand was 5,139MW recorded on May 23, 2003. This implies that there is huge excess capacity (over 3,500MW) and even a complete withdrawal of generation capacity by one of the three largest generators would leave some excess capacity so that the peak demand could be met by the residual supply. This huge excess capacity underlies that the power generation market in Singapore might be highly competitive though concentration measures suggest otherwise.

Table 1: Generation Capacity in Singapore, Authorized and Installed (2004)

<table>
<thead>
<tr>
<th>Company</th>
<th>Authorised Capacity (MW)</th>
<th>Installed Capacity (MW)</th>
<th>Market Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerSeraya</td>
<td>3,100</td>
<td>2,414</td>
<td>28.8</td>
</tr>
<tr>
<td>Senoko Power</td>
<td>3,300</td>
<td>2,980</td>
<td>35.5</td>
</tr>
<tr>
<td>Tuas Power</td>
<td>2,670</td>
<td>1,920</td>
<td>22.9</td>
</tr>
<tr>
<td>SembCorp Cogen</td>
<td>900</td>
<td>785</td>
<td>9.4</td>
</tr>
<tr>
<td>Island Power</td>
<td>800</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keppel Merlimau</td>
<td>470</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NEA</td>
<td>250</td>
<td>130</td>
<td>1.6</td>
</tr>
<tr>
<td>Other</td>
<td>150</td>
<td>150</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>11,640</td>
<td>8,379</td>
<td>100.0</td>
</tr>
</tbody>
</table>


Table 1 above and figure 1 below show that either Senoko Power or PowerSeraya is the dominant generating company by installed generation capacity followed by Tuas Power. In addition, the three largest generating companies have the lion’s share of the generating capacity in Singapore. This situation would raise a question that one of these large generators or a tacit coalition among these generators could have market power.

This section analyzes how competitive the New Electricity Market of Singapore (NEMS) is and it also examines whether market power exists in the NEMS by various measures of market power such as concentration ratios, modified measures of market shares and price-cost markups.

3.1 Concentration Ratio

As a concentration-cum-competition measure in a market, the four-firm concentration measure (CS4) or the eight-firm concentration measure (CS8) shows the sum of market shares accounted for by the four or eight largest firms in a market respectively. The CS4 is expressed as follows:

$$CS4 = \sum^{4}_{i=1} s_i$$, where $s_i$ is the firm $i$’s market share.  \hspace{1cm} (1)

The four-firm concentration measure (CS4) of Singapore’s generation market by the installed generation capacity is more than 96 percent. (The market share of the three largest companies by installed capacity ranges from 23 to 36 percent.) This implies that the market is highly concentrated.
As the CS4 has hinted above, the three largest power companies in Singapore – PowerSeraya, Senoko Power and Tuas Power – have about 88 percent of the installed generation capacity in the NEMS. Hence, during the first year of the NEMS in 2003 the market power of the generation companies has been checked by a mandatory 100 percent price cap set for the total demand, and the generation companies are not allowed to cause prices to rise beyond the price cap. However, they could use their market power to keep electricity prices to the allowed price cap. From January 1, 2004, the second year of the NEMS, vesting contracts are imposed on 65 percent of total demand. The vesting contracts impose a contractual obligation on the generation companies so that they have to produce a specified quantity of electricity. The effect of the vesting contracts is to cap the price of this 65 percent of total demand while the price for the remaining 35 percent is determined by competition in the wholesale market.

Though the CS4 shows the generation market of the NEMS is highly concentrated, it does not fully prove whether there exists market power in the NEMS, especially under the mandatory 100 percent price cap and the vesting contracts. This study employs other measures like Herfindahl-Hirschman Index (HHI), Supply Margin Assessment (SMA), Residual Supply Index (RSI) and the Lerner Index to examine the existence of market power in the NEMS in the following sections.

### 3.2 Herfindahl-Hirschman Index

The Herfindahl-Hirschman Index (HHI) is defined as the sum of the squares of the market share of firms in the industry. It shows the degree of a market concentration of a particular industry in a particular geographic region. It takes on a maximum value of one (monopoly) and approaches zero (perfect competition). The higher the HHI is, the more concentrated the market is, and the market is possibly less competitive. The HHI is expressed as follows:

$$HHI = \sum_{i=1}^{n} (s_i)^2$$, where $s_i$ is the firm $i$’s market share. \hspace{1cm} (2)

The HHI of Singapore’s generation market by the installed generation capacity is 0.2662. It is greater than a measure (0.18) regarded as highly concentrated by the U.S. Horizontal Merger Guidelines. This HHI is also greater than that of England and Wales where the HHI is 0.16.
and the number of firms is 32, but smaller than that of Sweden where the HHI is 0.32 and the number of firms is 8 (Besant-Jones and Tenenbaum, 2001). By the HHI, the generation market in Singapore is considered highly concentrated.

However, the inverse of the HHI may give a more intuitive interpretation as it gives the number of effective competitors. By the inverse of the HHI, the number of effective competitors in the NEMS is three or four. There are 8 generation licensees in Singapore including two small generators whose capacity is less than 500MW. Though the HHI shows the generation market in Singapore is highly concentrated, there are sufficient numbers for effective competition in the generation market.

From the concentration measures reviewed above, the generation market in Singapore could be considered highly concentrated, but in terms of effective competitors, there are sufficient players. It is inconclusive to judge market power exists in the NEMS. Hence, the study proceeds to test whether there is a pivotal supplier in the generation market.

### 3.3 Supply Margin Assessment

Supply Margin Assessment (SMA) tests whether a market’s peak day demand is met by without a seller’s generator in question. If a market’s peak day demand can be met without a seller’s generation in question, the seller is not pivotal in the market. In other words, if any of the firm’s capacity is needed to meet peak demand, then that firm has market power. The SMA can be expressed as follows:

\[
SMA_i = (D_p - \sum_{j} S_{i,j})
\]

where \( SMA_i \) is the supply margin in the market for firm \( i \), \( D_p \) is the market’s peak day demand and \( \sum_{j} S_{i,j} \) is the total generation capacity of the market without the firm \( i \)’s generation capacity. If the \( SMA_i \) is positive, the firm \( i \)’s capacity is pivotal in the market. By this indicator, none of power generators in the NEMS is pivotal.

Federal Energy Regulatory Commission (FERC) of the United States of America applied the SMA as a single definitive generation market power test. In 2004, the Commission finds a single definitive test is not an optimal approach to measuring generation market power and two indicative screens are adopted: a pivotal supplier analysis and a market share analysis. The pivotal supplier analysis evaluates the potential of an applicant to exercise market power based on the control area market’s annual peak demand, while the market share analysis assesses market power on the basis of an applicant’s share of the uncommitted capacity during each season.

The pivotal supply test, one of the two indicative screening tests tells that an applicant is considered pivotal if its capacity exceeds the market’s surplus of capacity above peak demand, the market’s supply margin. If an applicant fails this test, the applicant is a must-run supplier needed to meet the annual peak day load in the control area.

The market share analysis, another of the two indicative screening tests is applied on a seasonal basis and measures whether an applicant has the potential to exercise market power based on the applicant’s share of the total uncommitted capacity in the relevant geographical market. The calculation of uncommitted capacity for use in the market share analysis differs from that used in the pivotal supplier analysis in two aspects: first, the proxy for native load is the minimum peak load day for each season considered, and second, applicants may deduct
for planned outages. An applicant with a market share of less than 20 percent for all seasons passes. If any firm fails the screening tests, it can appeal for further test – delivered price test. Under the delivered price test, if price is 5 percent greater than actual price, the firm is considered to have market power.

By these two indicative screens for measuring market power, none of the generators in the NEMS fails as well. In the next section, another measure for testing market power, Residual Supply Index (RSI), is examined to verify the non-existence of market power suggested by the SMA.

### 3.4 Residual Supply Index

Residual Supply Index (RSI) for each generator is calculated by dividing the total supply offered by all generators other than the generator in question by the quantity demanded in a given specific hour. The RSI can be expressed as follows:

$$ RSI_i = \frac{\sum S_{-i}}{D_p}, $$

where $RSI_i$ is the residual supply index of the firm $i$, $\sum S_{-i}$ is the total supply offered by all generators other than the generators of the firm $i$ in question and $D_p$ is the quantity demanded in a given hour $t$. If the RSI is less than one, the generator in question is pivotal. As the RSI decreases, market power of the generator in question increases.

Using data on peak load (5,139W) and installed capacity by generating companies given in table 1, RSI in the NEMS is calculated and table 2 shows the RSI by company in 2004. In Singapore, the RSI is greater than one by any generator. This RSI is based on total capacity of the year and expected peak load of the year. Hence, actual RSI based on available capacity and the quantity demanded in a given hour would be slightly different.

<table>
<thead>
<tr>
<th>Company</th>
<th>RSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerSeraya</td>
<td>1.16</td>
</tr>
<tr>
<td>Senoko Power</td>
<td>1.05</td>
</tr>
<tr>
<td>Tuas Power</td>
<td>1.26</td>
</tr>
<tr>
<td>SembCorp Cogen</td>
<td>1.48</td>
</tr>
<tr>
<td>Island Power</td>
<td>1.63</td>
</tr>
<tr>
<td>Keppel Merlimau</td>
<td>1.63</td>
</tr>
<tr>
<td>NEA</td>
<td>1.61</td>
</tr>
<tr>
<td>Other</td>
<td>1.60</td>
</tr>
</tbody>
</table>

California Independent System Operator (CAISO) considers that the market will be fairly competitive when RSI is significantly above 1 (usually at 1.2 or more). Table 2 shows that the RSI in the NEMS based on each company’s generation capacity in 2004 is ranging from 1.05 for Senoko Power to 1.61 for NEA (excluding two generation companies that are not in operation yet). The RSI is slightly above 1 for the two largest generation companies and that for the remaining generation companies is greater than 1.2. This implies that the largest
supplier or a few of the large suppliers ‘jointly’ could still have significant market power in 2004 though the chance seems to be pretty slim.

In sum, though the generation market in Singapore is considered highly concentrated by installed capacity, SMA shows that there is no pivotal supplier in the market and RSI is above 1 for the two largest generation companies and above 1.2 for the rest of the generation companies. When a firm has market power, it could increase market price by exercising market power or withdrawing its capacity. Hence, this study examines how actual market prices are diverging from a firm’s marginal cost of supply in the next section.

3.5 The Lerner Index

The Lerner Index is the relative markup and is defined as the difference between price and marginal cost as a fraction of price. It measures a firm’s ability to maintain prices above competitive level at its profit-maximizing level of output. The Lerner Index of zero means a firm does not have market power while one means the firm has infinite market power. The Lerner Index could give a more meaningful explanation on the dominance or abuse of market power in the NEMS, but its calculation requires firm-level cost information, which is highly confidential.

Two types of marginal costs are used in the calculation of the Lerner Index – short-run marginal cost and long-run marginal cost. The calculation of both the short-run and long-run marginal cost is based on a combined cycle gas turbine under the most efficiently configured power plant. The value of the long-run marginal cost has been posted for public consultation by the Energy Market Authority of Singapore (Energy Market Authority, 2004). The value of the short-run marginal cost is calculated based on the data appeared in the calculation of the long-run marginal cost and other efficiency-related data publicly available from generation and turbine industry.

The period considered for the Lerner Index calculation is from 01 January 2003 to 15 June 2004. The price used is the Uniform Singapore Electricity Price (USEP) on half-hour base. For the entire period, the number of observations is 25,536. Average price for the entire period is S$86.60/MWh. Average price in 2003 is S$92.40/MWh and S$73.90/MWh in 2004. The average price of USEP in 2004 is less than long-run marginal cost suggested by the EMA as a benchmark price for vesting contracts that have been implemented since 01 January 2004.

The Lerner Index is calculated by the following formula: the difference between price and the short-run marginal cost is divided by the price. The Lerner Index can be expressed mathematically as follows:

\[ L_x = \frac{P - MC}{P}, \]

where \( L_x \) is the Lerner Index or price-cost markup, \( P \) is the market price and \( MC \) is the supplier’s marginal cost calculated at its actual level of output.

There are a few cases where the USEP is zero or near zero, even negative. As these extreme values could distort the would-be true value of the price-cost markups, it is assumed in the calculation of price-cost markups that if price is less than short-run marginal cost, the calculated Lerner Index is considered zero.\(^{iii}\)

Table 3 below shows the calculated price-cost markups in the NEMS from January 2003 to June 2004. The price-cost markups for 2003 are higher than that of entire period while that of
2004 is the lowest. The markups are higher than 20 percent for both the entire period and 2003 while that of 2004 is far below 20 percent. This implies that the USEP is more than 25 percent higher than the generator’s marginal costs in 2003, while barely more than 10 percent in 2004. The price-cost markups for 2004 are barely one half of the price-cost markups in 2003. The lower average USEP in the first 6 months of 2004 attributes the smaller price-cost markups. The short-run marginal cost used for the calculation of the price-cost markups is based on the most efficiently configured combined-cycle gas turbine power plant. Hence, this estimation of price-cost markups is the upper bound of price-cost markups in the NEMS.

Table 3: Price Cost Markups \([\frac{P-MC}{P}]\)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>With SRMC</th>
<th>With LRMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Period</td>
<td>0.213 (0.131)</td>
<td>0.05 (0.105)</td>
</tr>
<tr>
<td>2003</td>
<td>0.254 (0.134)</td>
<td>0.07 (0.118)</td>
</tr>
<tr>
<td>2004 (until June 15)</td>
<td>0.123 (0.091)</td>
<td>0.006 (0.042)</td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses are Standard Deviations. \(P=0\) is excluded.

When the price-cost markup is multiplied by the price elasticity of demand, it becomes the elasticity-adjusted price-cost markup, which shows how the generators exercise market power. The elasticity-adjusted price-cost markup is zero if there is perfect competition and the inverse of the elasticity-adjusted price-cost markup is interpreted as the “equivalent number of firm” in the industry. If the short-run price elasticity of demand for electricity in the NEMS is assumed -0.2, the elasticity-adjusted price-cost markup in the NEMS would be 0.05 and 0.025 for 2003 and 2004 respectively. This implies that the generators exercise very little market power, especially in the first six months of 2004.

Table 4 below presents the price-cost markups in the British electricity spot market (Wolfram, 1999). The price-cost markups in the NEMS under the most efficiently configured combined cycle gas turbine are pretty close to that of the British Electricity Spot Market. However, the price-cost markup for 2004 alone is pretty lower than that of the British Electricity Spot Market.

Table 4: Price-Cost Markups in the British Electricity Spot Market

<table>
<thead>
<tr>
<th>Time Period</th>
<th>((\frac{P-MC}{P}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1992 – March 1993</td>
<td>0.241 (0.129)</td>
</tr>
<tr>
<td>April 1993 – March 1994</td>
<td>0.259 (0.228)</td>
</tr>
<tr>
<td>After March 1994</td>
<td>0.208 (0.416)</td>
</tr>
</tbody>
</table>


Wolfram (1999) also presents that the elasticity-adjusted price-cost markups of the British Electricity Sport Market range from 0.043 to 0.067. This suggests that the generators exercise very little of market power during those periods. If the elasticity-adjusted price-cost markup is 0.05, the industry is considered a 20-firm symmetric Cournot oligopoly.

As shown in table 3 in previous page, with long-run marginal cost, the price-cost markups are less than 10 percent. One thing to note is that the markups are even less than one percent in 2004. This low value of the price-cost markups could infer that the generation market in Singapore resembles a perfectly competitive market.

The positive price-cost markups with long-run marginal cost, however, infer that a generator could manage to get economic profits. The recently implemented vesting contracts could
attribute to the underlying lower markups with long-run marginal cost. Hence, lower amounts in vesting contracts could increase the price-cost markups with long-run marginal cost and generator’s profitability. But the generator’s higher profitability comes at the cost of consumers.

If expected merits order of individual generators were constructed based on their short-run marginal cost of supply, it would show more realistic figures of market power in the NEMS. If there were many identical generators around peak demand, then the would-be-gains from market power might not be necessarily accrued to the initiator of market power. Hence, actual possibility of market power being exercised would be pretty slim.

In sum, some measures of market power like CS4 or HHI hint that there might be market power in the NEMS, while some measures like SMA, RSI or the Lerner Index do not strongly support the existence of market power in the NEMS. In the first year of the NEMS, a mandatory 100 percent price cap was imposed and vesting contract were imposed in the following year as a way of mitigating market power in the NEMS. In the following section, how the recently imposed vesting contracts in the NEMS affect competition and electricity price levels in the wholesale electricity market is examined along with evaluation of the gains in economic efficiency under new market structure.

IV. Vesting Contract, Competition and Efficiency in the NEMS

Vesting contracts have been imposed in the early days of deregulated electricity markets to protect consumers from volatile electricity prices due to abuse of market power by a dominant market player. There are a few countries that have implemented vesting contracts. This section reviews experiences with vesting contracts in other countries and examines possible economic gains under a mandatory 100 percent price cap during 2003 and vesting contracts in 2004 in the NEMS.

4.1 Vesting Contracts in Other Countries

Australia is one of these countries where vesting contracts were implemented. There were two types of vesting contracts in Australia. The Type 1 contracts are two-way hedge contract with an average strike price. When spot price is above the strike price, generators reimburse the difference to retailers; when spot price is below the strike price, retailers reimburse generators. The Type 2 contracts are applied during weekday peak periods and equivalent periods on weekends and public holidays. Between 13 and 25 percent of the franchise load are covered by the Type 2 contracts and these contracts incorporate a price cap, based on the same price in the Type 1 contracts, and a floor price which operates as a binary option. Under the Type 2 contracts, generators receive the full floor price plus the spot price, whenever the spot price is below the floor price. At spot prices at or above the floor price, generators receive the spot price, but only up to the limit set by the one-way price cap in favour of retailers. When the spot price is at or above the price cap, retailers receive from generators the difference between the spot and strike prices.

Wolak (2000) analyzed the impact of hedge contracts on bidding behaviour in the first three months of operation of the National Electricity Market of Australia. The study provides strong evidence for the effectiveness of financial hedge contracts as a means to mitigate market power during the initial stages of operation of a wholesale electricity market. Regulators can restrict market power of generators by enforcing sufficient amount of vesting contracts. However, too much hedge contracts (vesting contracts) would lead to too aggressive bidding which may lead to low price that is possibly lower than marginal costs, which is not beneficial for generators. Hence questions like how optimal an amount of vesting
contracts is, what should be the optimal sequence in reducing the levels of such contracts over time, and how prices will adjust are still open and need to be answered.

New Zealand is another country that has implemented vesting contracts during the early days of deregulation. There is a financial pool where buyers and sellers hedge risks on voluntary basis. A centralised trading platform for electricity derivative contracts was launched by the four largest electricity generators in New Zealand -- Contact Energy, Genesis Power, Meridian Energy and Mighty River Power. This development has the intention of enhancing existing electricity hedge markets and providing further price transparency. The four generators trade a standardised Contract for Difference (CfD).

Since January 2004, the NEMS has implemented vesting contracts. Vesting contracts are a contractual obligation of the generation companies to produce a specified quantity of electricity. Currently 65 percent of total electricity demand is vested and non-contestable consumers are fully covered by the vesting contracts. The amount vested constitutes 30 percent of the installed generation capacity. The price of the remaining 35 percent of demand is determined by competition in the wholesale market.

A study by California Independent System Operator (CAISO) finds that there is a negative relationship between the residual supply index (RSI) and the price-cost markup (Sheffrin, 2001). The RSI is calculated by hourly supply and demand balance considering the largest supplier’s market share of available capacity rather than nameplate capacity. The nameplate generation capacity tends to inflate RSI as dependable or available capacity is less than the nameplate capacity. The study finds that the higher the RSI, the lower the price-cost markup. Specifically, the average price-cost markup is about zero when the RSI is about 1.2. Hence, the lower RSI implies higher market power that would be translated into higher price-cost markup.

The underlying negative relationship between the RSI and the price-cost markup suggests that higher price-cost markups would verify the existence of market power. Hence, lower price-cost markups in the NEMS for the first six months of 2004 could be the result of mitigated market power, which is in turn an outcome of the vesting contracts as they put downward pressure on prices as shown in table 5 below.

As table 5 below shows, the average price in 2004 is far lower than that of 2003. As consumers could enjoy lower electricity prices, vesting contracts are definitely beneficial to consumers. As the price-cost markups have shown, however, whether vesting contracts work for generators is questionable. The price-cost markups present the magnitude of the markups has shrunk in 2004 compared to 2003 when no vesting contracts were imposed. As shown in table 3 in previous page, the price-cost markups with long-run marginal cost in 2004 (0.006) are even close to zero compared to that (0.07) in 2003. This may suggest that the generators are not likely to get much profit with current level of vesting contracts.

<table>
<thead>
<tr>
<th>Period</th>
<th>USEP (S$/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003 (No Vesting Contracts)</td>
<td>92.4</td>
</tr>
<tr>
<td>2004 (until 15 June 2004, with Vesting Contracts)</td>
<td>73.9</td>
</tr>
</tbody>
</table>

The underlying lower price-cost markups in 2004 compared to that of 2003 also reflect the lower average USEP in 2004. The annual electricity consumption in the NEMS is 31,089.7GWh and 31,985.7GWh in 2002 and 2003 respectively. Out of the total electricity
consumption, non-domestic electricity consumption is 24,741.7GWh and 25,478.6GWh in 2002 and 2003 respectively. If an arithmetic average of two years’ electricity consumption is assumed for the electricity consumption in 2004, the expected non-domestic electricity consumption is 25,110.2GWh. The lower USEP in 2004 would have caused the reduction in operating revenues by S$464.5 millions. This could be a significant amount of operating revenues of generating companies.

Vesting contracts must be a powerful and effective tool to mitigate market power and reduce price volatility. However, the lower price-cost markups would have detrimental effect on incumbent generators’ profits and discourage new entrants. The possible savings for consumers via vesting contracts would come at the cost of power producers. How to balance between gains to consumers and losses to producers is an agenda for further implementation of vesting contracts.

4.2 Economic Gains in the New Market Structure

The new electricity market structure in Singapore could bring economic gains in production and consumption as discussed in section II. A deregulated electricity market is believed to bring efficiency gains through competition. New electricity market structure with vesting contracts would definitely give some benefits to consumers in the form of lower prices as shown in lower average USEP during the first six months of 2004.

To calculate possible gains in production cost, a least-cost production model of the NEMS is used (Chang and Tay, forthcoming). The study estimates production efficiency gains by solving the total discounted cost minimization problem (the least total discount cost model) under two scenarios: one with and the other, without deregulation. The least cost options are to be chosen among the given generation technologies with their attendant operating and capital costs, availability rates, capacities and other parameters. It also compares the model results with the trend adopted by the industry. For example, if the model yields CCGT plants as the most economical plant available, it could be suggested that the generation companies are indeed moving towards building such plants. The study calculates the sum of total operating and capital costs discounted over the time horizon of 30 years, which is from 2002 to 2032. The discount rate is set at 5 percent. There are two blocks of demand – peak and non-peak, and demand is assumed to grow at 4 percent per year. The study shows that the discounted electricity production costs under 20 percent reserve margin would be lower than that under 30 percent reserve margin. However, the cost difference is less than 1 percent of total production cost. The majority of reductions in production cost would come from lower operating cost that would reflect higher competition through the new market structure. Lower reserve margin would reduce production cost and increase production efficiency.

Singapore’s electricity market has changed from a day-ahead market (Singapore Electricity Pool: SEP) to a real time spot-market (NEMS). With two-stage least squares regression analysis, price-responsive ness of contestable and non-contestable consumers are examined (Chang and Tay, 2004). For contestable consumers, half-hourly price and quantity data from 01 July 2001 to 31 October 2002 and from 01 January 2003 to 09 February 2004 are analysed. For non-contestable consumers, quantity data is derived by subtracting that of contestable consumers from the total demand and tariffs rates are used as price data. Under the SEP, contestable consumers were responding to price changes, but the magnitude is pretty small (-0.0009). Though the price elasticity of demand is negative and statistically significant, it is considered highly inelastic. Under the NEMS, however, it is shown that the magnitude of price responsiveness has increased (-0.0016) though it is still highly inelastic. This price elasticity of demand is pretty low compared to that of other countries, which is in the range of -0.2 to -0.7. The study finds that non-contestable consumers are not responding to changes in tariffs under SEP while they are responding to changes in tariffs under the NEMS. In sum,
though small, the increase in price responsiveness among contestable consumers could prove that a price that varies throughout the day would persuade consumers to delay or reduce consumption when the good is expensive. Hence, the NEMS would yield greater consumption efficiency as the market becomes close to full competition.

V. Conclusion

The generation market of the New Electricity Market of Singapore (NEMS) appears highly concentrated by the measures of market power like the four-firm concentration ratio or the Herfindahl-Hirschman Index (HHI). However, by the inverse of the HHI, the market seems to have a number of effective competitors. In addition, Supply Margin Assessment (SMA) confirms that there is no pivotal supplier in the generation market of the NEMS and the Residual Supply Index (RSI) also confirms that the market is competitive though there are some possibilities in which the largest generator or a few large generators jointly could still have market power. The Lerner Index or the price-cost markups of the NEMS show that the generation market of the NEMS is fairly competitive. When an industry level price elasticity of demand is applied to the price-cost markups, it is shown that there has not been much exercise of market power.

Vesting contracts are believed to be a strong and effective tool to mitigate market power, provided that there has been market power in the NEMS. The average level of USEP in 2004 is about S$18 lower than that in 2003 and the vesting contracts are the force behind the lowering in the average USEP and the price-cost markups in 2004. A simple interpolation gives the possible decrease in operating revenues collectively for generating companies to be S$464.6 millions. The new electricity market structure is also believed to deliver economic gains such as decrease in power generation cost and higher price-responsiveness. However, whether the expected economic gains are realised remains to be seen.

Compared to international exercise in reserve margins which range from 14 percent to 21 percent, there are excess capacities larger than required reserve margins in the NEMS and the lowering in the reserve margins would bring some gains. Simulations with a least cost production model present that there would be expected gains in power production costs over the 30-year time horizon, but the magnitude of the gains are pretty small so that keeping the excess capacity may not incur huge costs. However, the lowering of the reserve margins could reduce the capital cost and thus, increase generating companies’ profitability. The new market structure also suggests that price-responsiveness of consumers in the NEMS would increase as the market moves to the full competition mode. When the price-cost markups and the RSI are applied together, a schematic framework for determining optimal reserve margins could be established. This would be further explored with calculation of hourly RSI and setting up of a standard in the price-cost markups for workable competition.
References


Sheffrin, Anjali (2001): “Preliminary study of reserve margin requirements necessary to promote workable competition,” mimeo, Market Analysis, CAISO.


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i SP PowerGrid used to be called PowerGrid.

ii SP Services used to be named Power Supply Ltd but its name was changed when it shed its retailer role to be a provider of market support services.

iii When all positive and negative prices are considered (except the cases that price is zero), price-cost markups are negative in 2003. When even only positive prices are considered, price-cost markups are negative in both 2003 and 2004. These two cases are not covered in this study.

iv The California Independent System Operator (CAISO), in their preliminary study on promoting workable competition, defined a workable competitive market where the average annual price-cost markup is less than 10 percent. [Sheffrin, Anjali (2001): Preliminary study of reserve margin requirements necessary to promote workable competition, mimeo, CAISO]

v The value of the short-run price elasticity of demand for electricity is taken from Bohi (1981)’s estimation of aggregate industrial electricity demand. The share of non-domestic electricity demand in Singapore is about 80 percent of total demand. Hence, this assumption of the price elasticity may not be too over-estimated. One study finds the price elasticity of demand for electricity of contestable consumers in Singapore is -0.0016 (Chang and Tay, 2004).