



Introduction to the National Electricity Market of Singapore

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DOCUMENT HISTORY

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Version 4.0	Posted on EMA website	13 Jan 2006
Version 5.0	Posted on EMA website	Jul 2009

1. *DISCLAIMER*

This document is not a complete statement of the structure or design of the new Singapore electricity market and simplifies many of the details for the sake of brevity. While every attempt has been made to ensure its accuracy, this overview should not be relied upon for business decisions related to the new Singapore electricity market. It does not replace the Electricity Act (Cap 89A), the Energy Market Authority of Singapore Act (Cap 92B), any other legislation or regulations, the wholesale market rules, electricity licences or codes of practice or other standards of performance. The above legislation and documents are the official statements of how the new Singapore electricity market operates and defines the obligations of participants in this new market. Where discrepancies or inconsistencies exist between this overview and any one or more of the legislation/ documents mentioned above, these legislation/documents would prevail. Readers are also advised that the market itself is expected to be dynamic and to change over time. This overview is current as of the date noted on the first page, but may eventually be overtaken by events in the marketplace.

2. SUMMARY

2.1 PURPOSE OF THIS DOCUMENT

This document provides an overview of the National Electricity Market of Singapore (NEMS). Our aim is to enable interested parties to gain an understanding of what NEMS is, what the wholesale and retail markets are and how they work. As such, it is largely a non-technical description to be used as a starting point for understanding the NEMS and market arrangements. Some readers may use this overview as a precursor to studying the market rules, electricity licences, codes of practice and other market documentation in more depth. Others may use it as an educational reference.

2.2 THE NATIONAL ELECTRICITY MARKET OF SINGAPORE

The NEMS is designed to promote the efficient supply of competitively-priced electricity, open up the retail market to full competition, allow certain government-owned assets to be privatised, and encourage private investment in Singapore's power system infrastructure.

Since 1995, the power system assets have been structured to facilitate commercialisation and subsequent privatisation. As at end Dec 2008, Temasek Holdings has divested all three power generation companies previously owned by it.

In 1998, the Singapore Electricity Pool, a day-ahead electricity market, came into operation. The NEMS, which commenced in 2003, represents a progression from the Pool to fully competitive wholesale and retail electricity markets.

The NEMS is established under the authority of the Electricity Act, and is largely governed by that Act¹. In addition, it is governed by the wholesale market rules and associated manuals and by the electricity licences and codes of practice issued by the Energy Market Authority (EMA).

The EMA was established under the Energy Market Authority of Singapore Act and the Electricity Act allocates to the EMA responsibility for regulation of the electricity sector.

Authorisation for an entity to conduct most electricity-related functions is via an electricity licence issued by the EMA. The electricity licences require that licensed entities comply with relevant codes of practice and other standards of performance that govern their activities.

The EMA was also responsible for making the initial set of wholesale market rules which, along with market manuals, the system operation manual and specific market-related agreements, provide for the establishment and operation of the wholesale electricity market. They also govern the conduct of the Energy Market Company (EMC), the Power System Operator (PSO), market participants and market support services licensees (MSSLs) in that market.

2.3 NATIONAL ELECTRICITY MARKET OF SINGAPORE STRUCTURE

The NEMS comprises a wholesale market and a retail market.

¹ Also, to a lesser degree, by the Energy Market Authority of Singapore Act (Cap 92B).

2. Summary...

2.3.1 Structure of the Wholesale Market

The wholesale market actually comprises two markets:

- The “real-time market” or spot market for energy, regulation and reserve; and
- The “procurement market” for other ancillary services.

In the spot market, buyers and sellers trade in energy, reserve and regulation through the EMC. In the “procurement market”, the EMC procures by contract, on behalf of the PSO, ancillary services (other than reserve and regulation) required to maintain the secure operation of the power system.

Unless we state otherwise, the remainder of this document describes the real-time or spot market rather than the procurement market.

The real-time market uses a form of auction pricing to settle transactions in the market. This encourages the economically efficient scheduling of generation facilities in the short term, and provides incentives for new power system investment in the long term. The market is designed to be robust, transparent, equitable and cost-effective to run.

Every half-hour the spot market determines:

- The dispatch quantity that each generation facility is to produce;
- The reserve and regulation capacity required to be maintained by each facility²; and
- The corresponding wholesale spot market prices for energy, reserve and regulation.

These quantities and prices are based on price-quantity offers made by generators and load forecasts prepared by the EMC based on demand forecast information received from the PSO.

The overall least-cost dispatch schedule and market prices are determined each half-hour by a computer model called the Market Clearing Engine (MCE). The MCE takes account of a full range of system constraints and generates energy prices – referred to as nodal prices - that will vary at different points on the network. The differences in nodal energy prices reflect the transmission losses and physical restrictions on the transmission system.

- Each dispatchable generator³ is paid the market price for energy at the node to which it has been assigned.
- Each generator or load facility that has been registered to provide reserve or regulation is paid the market price for reserve or regulation. The price for reserve varies according to the class of reserve and reserve group to which the facility belongs⁴.

² For reserve, a facility may be a generating unit or an interruptible load.

³ All generation facilities at the same location with an aggregate name-plate rating of 10 MW or more are required to be dispatchable. Generation facilities at a single location with a name-plate rating of 1 MW or more but less than 10 MW can opt to be dispatchable or non-dispatchable.

⁴ Load facilities were not able to be registered at the time of commencement of operation of the real-time market. From 1 January 2004, load facilities can be registered to provide interruptible load.

2. Summary...

- Buyers pay the Uniform Singapore Energy Price (USEP) for energy. This is a weighted-average of the nodal prices at all off-take nodes.
- The payments for reserve are made by generation units according to how much they impose to the need for that service.
- Regulation is paid by loads (and to a minor degree by generators).

2.3.2 Structure of the Retail Market

The retail market is being introduced in stages.

Initially, the industry structure has been set up to facilitate full retail competition with licensed retailers, a MSSL and some consumers able to choose their retailer.

Since July 2001, consumers with a maximum power requirement of 2MW and above were already given the option to choose whom they wish to buy electricity from. In June 2003, consumers with average monthly consumption of 20,000kWh and above became contestable. The size threshold for consumers to be contestable was lowered again in December 2003, allowing consumers with average monthly consumption of 10,000 kWh and above to become contestable. This arrangement gives retailers' incentives to operate more efficiently and to innovate to meet their customers' needs. Retail competition for rest of the smaller consumers (about 1 million consumers in total) is currently being studied.

Non-contestable consumers are supplied by the MSSL.

2.3.3 Structure of the Transmission System

There is one transmission licensee, SP PowerAssets, which currently owns and maintains the transmission system in Singapore. The transmission system comprises a high voltage network (referred to elsewhere as the transmission network) and a low voltage network (referred to elsewhere as the distribution network). SP PowerAssets appointed SP PowerGrid, also a member of Singapore Power Group, to manage its business including the management and operation of the transmission network and distribution network. The transmission system is a natural monopoly, and SP PowerAssets is therefore subject to price regulation.

To ensure open and non-discriminatory access to the transmission network in the NEMS, the PSO will direct the operation of the high voltage transmission network⁵ while SP PowerAssets will continue to own, operate and maintain the complete transmission system.

2.4 PARTIES TO THE NATIONAL ELECTRICITY MARKET OF SINGAPORE

The parties in the NEMS will be:

- *The regulator:* The EMA is the Regulator of the electricity sector and has the ultimate responsibility of ensuring that the NEMS meets the needs of Singapore.
- *The market operator:* The EMC is the company that operates and administers the wholesale markets. It is owned by the EMA and M-Co of New Zealand, with EMA having majority ownership.

⁵ More precisely, the PSO operates that part of the transmission system that corresponds with the nodes and lines in wholesale market system.

2. Summary...

- *The power system operator:* The PSO (a division of the EMA) is responsible for ensuring the reliable supply of electricity to consumers and the secure operation of the power system. The PSO controls the dispatch of facilities in the wholesale market, coordinates outage and emergency planning and directs the operation of the Singapore high-voltage transmission system under the terms of an “operating agreement” with SP PowerAssets, the transmission licensee.
- *The transmission licensee:* SP PowerAssets owns and is responsible for the operation and maintenance of the transmission system⁶.
- *Generation licensees:* All generators with any facility with a name-plate rating of 10 MW or more must be licensed by the EMA. All facilities of 10MW or more must be registered for dispatch. Mandatory participation ensures that all generators of any significant size are subject to the market rules. Generators with facilities of 1MW or more but less than 10MW, or those who wish to get paid for the electricity exported to the grid are required to hold a Wholesale (Generation) licence. These generators register with the EMC either for dispatch or for settlements only.
- *Market support services licensees:* MSSLs provide market support services such as meter reading and meter data management. They also facilitate access to the wholesale market for contestable consumers and retailers, and are responsible for supplying electricity to all non-contestable consumers. SP Services Ltd (formerly known as Power Supply Ltd), is the only MSSL. The MSSL maintains a central register of all consumers in Singapore.
- *Retail electricity licensees:* Retailers are permitted to sell electricity to contestable consumers. Market Participant Retailers (MPRs) are required to be licensed by the EMA and to be registered with the EMC as a market participant in order to purchase electricity directly from the wholesale market. Non-Market Participant Retailers (NMPPRs) are required to obtain a license from the EMA and will purchase electricity indirectly from the Wholesale Electricity Market through the MSSL.
- *Consumers:* Consumers are categorised into contestable and non-contestable, depending on their annual electricity usage. Contestable consumers may purchase electricity from a retailer, indirectly from the wholesale market through a MSSL or directly from the wholesale market (provided in the latter case that they are registered with the EMC as market participants). Non-contestable consumers are required to be supplied by a MSSL.

2.5 WHOLESALE MARKET GOVERNANCE

Operation of the wholesale market is the responsibility of the EMC. The EMC is governed, in this respect, not only by the market rules but also by its constituent documents.

In certain cases, the market rules require that the Board of Directors of the EMC itself take action. In other cases, the market rules allocate responsibility to persons or panels appointed by the EMC.

The EMC is required to appoint a dispute resolution counsellor to oversee and assist in managing the dispute resolution process contained in the market rules and to facilitate the resolution of disputes.

⁶ This includes both the high and low voltage networks.

2. Summary...

The external market surveillance and compliance panel (comprising persons independent of the marketplace), along with the EMC's internal market assessment unit, are responsible for monitoring, investigating and reporting on the behaviour of market participants and market support services licensees with a view to identifying inappropriate or anomalous behaviour. They also have the task of monitoring the marketplace generally in order to detect deficiencies in the market design.

The process by which the market rules are modified is largely the responsibility of the EMC-appointed rules change panel, although the Board of Directors of the EMC retains ultimate authority in respect of rule changes subject only to approval by the EMA. The rules change panel includes a cross-section of market participants and a market support services licensee as well as consumer representatives to ensure that the interests of the various sectors of the industry are adequately represented.

2.6 BILATERAL CONTRACTING AND VESTING CONTRACTS

The market encourages bilateral hedge contracting. Some forms of these contracts can, at the discretion of the parties, be settled through the EMC's settlement process.

There are special financial contracts, called "vesting contracts", that EMA has imposed on the three large generators⁷ by condition of their electricity licences, and that will apply in the wholesale market.

- The vesting contracts are designed to reduce the market power of the large players.
- The pricing provisions of the vesting contracts are intended to reflect the economics of new generation plant.
- The quantity of hedges allocated to the generators under the vesting contracts reduces as the market power of the large generators diminishes.
- SP Services Ltd, the MSSL, is the counterparty to the generators in all of the vesting contracts, which are settled between the parties through the EMC's settlement system.
- SP Services Ltd allocates the net benefits or costs of the vesting contracts to the retailers, the non-contestable consumers and the contestable consumers who purchase electricity from the pool.

⁷ Senoko Power, PowerSeraya and Tuas Power.

3. BACKGROUND

In the context of the NEMS, it is relevant to briefly examine the development of the Singapore electricity sector and marketplace up to the time of restructuring, and the role of the electricity industry in the Singapore economy.

3.1 THE INDUSTRY REFORM PROCESS

3.1.1 Role of the Electricity Industry in Singapore

The electricity industry plays a significant role in the Singapore economy. With its history of rapid growth and expanding demand for domestic and commercial energy, Singapore is very reliant on an efficient and modern electricity system. The reliable supply of electricity, at a competitive price, influences the ability of Singapore industry to compete domestically and internationally, which in turn has a direct impact on the national economy.

The current restructuring programme was conceived out of the quest for an efficient supply of competitively priced electricity driven by an entrepreneurial industry. The privatisation of some Government-owned assets, and the encouragement of investment by international electricity companies experienced in operating in a competitive market, is expected to enhance Singapore's reputation as a low risk commercial environment with a modern competitive infrastructure.

3.1.2 Overview of Industry Reform Process

The electricity and piped gas industries in Singapore have traditionally been vertically integrated and Government-owned. The Public Utilities Board (PUB) was formed in May 1963 to undertake the supply of water, electricity and piped gas to the population of Singapore.

The first reform of the electricity industry was in 1995 when the Government corporatised the electricity undertakings of the PUB. The intention was to gradually introduce competition in electricity generation and retail so that Singapore would have an electricity market that allows market forces rather than central planning to drive investment, production and pricing decisions. In this first reform, the electricity and gas undertakings of the PUB were vested under the Government's investment arm, Temasek Holdings, while the PUB was reconstituted to undertake the new role of regulating the electricity and piped gas industries.

Within Temasek Holdings, Singapore Power was created as the holding company for several other new companies including the generation companies, PowerSenoko (now known as Senoko Power) and PowerSeraya; the transmission company, PowerGrid (now known as SP PowerAssets); and SP Services Ltd, the electricity supply and utilities support services company. A further generator, Tuas Power, was set up as an independent company directly under Temasek Holdings.

The second phase of the reform was implemented on 1 April 1998 when the Singapore Electricity Pool commenced operation. The Pool operated as a wholesale electricity market to facilitate the trading of electricity between generators and SP Services Ltd in a competitive environment. The Pool was a "day-ahead" market, with PowerGrid (as the owner of the electricity grid network, the pool administrator and the system operator) taking responsibility for operating the transmission system. The companies competing in the market were almost exclusively Government-owned. The pool introduced the

3. Background...

Singapore electricity industry to many of the attributes of a modern market without the full complications of a real-time spot market at the wholesale level, and provided a stepping-stone to the next stage of reform.

In September 1999, the Government carried out a comprehensive review of the electricity industry. The key objective of the review was to consider whether to implement a wholesale electricity market structure and regulatory framework to support a competitive electricity industry in Singapore.

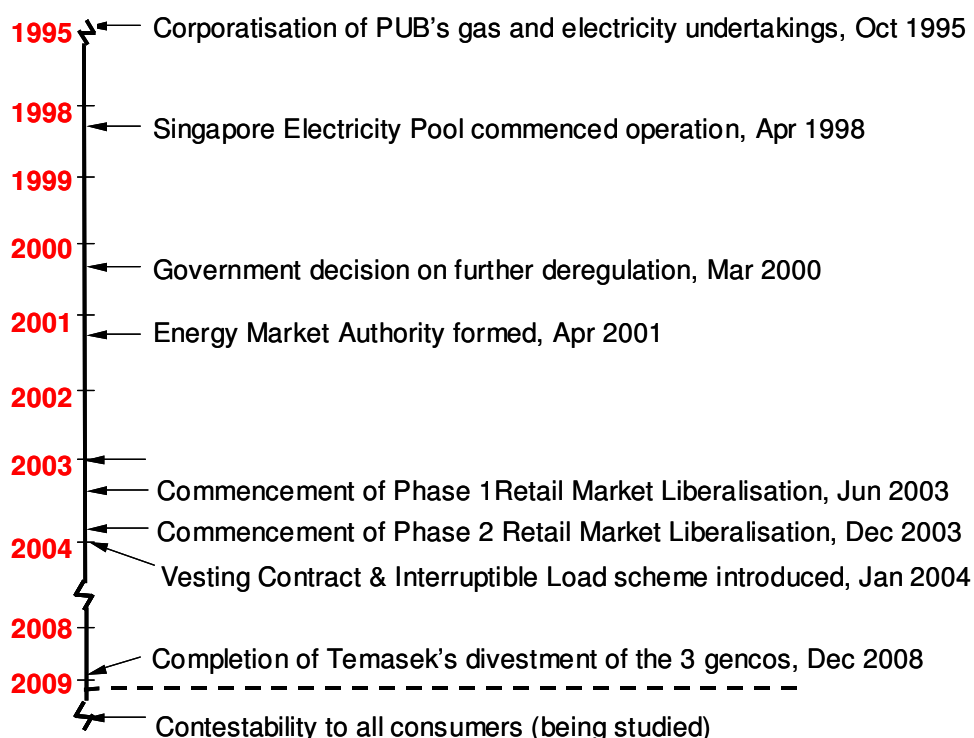
Following the review, the Government decided in March 2000 to continue with further deregulation of the industry to obtain the benefits of full competition. The key restructuring initiatives include:

- The separation at the ownership level of the contestable and non-contestable parts of the electricity industry;
- The establishment of a system operator and market operator;
- The establishment of a real-time wholesale market; and
- The liberalisation of the retail market.

Simultaneously, the Government decided to restructure the gas industry to put in place a competitive market framework to complement the liberalisation of the electricity industry.

On 1 April 2001, PUB was restructured into a comprehensive water authority under the Ministry of the Environment, and a new statutory body called the EMA was established. The EMA is responsible for regulating the electricity and gas industries and, in its capacity as PSO, for ensuring the secure operation of the power system. The EMC, a joint venture of the EMA and M-co Pte Ltd, is responsible for the operation and administration of the wholesale electricity market.

Figure 1. Timeline for deregulation of the Singapore electricity industry



4. OVERVIEW OF THE NATIONAL ELECTRICITY MARKET OF SINGAPORE

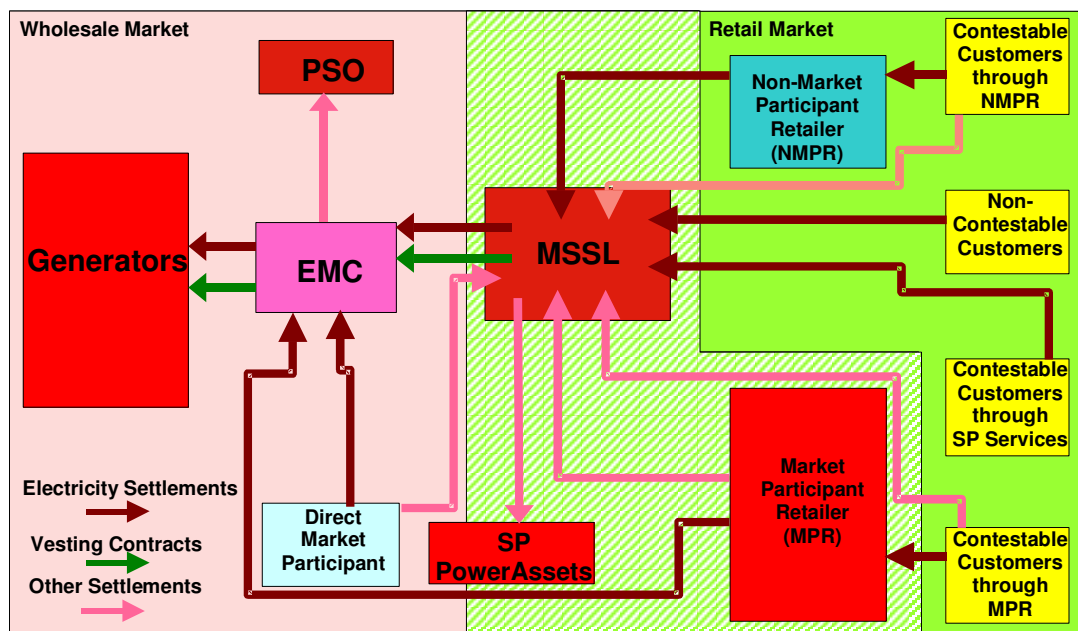
This section presents an overview of NEMS - the various institutions in the NEMS as well as some operational aspects of the wholesale electricity market and the retail electricity market.

4.1 INSTITUTIONAL OVERVIEW OF THE NATIONAL ELECTRICITY MARKET OF SINGAPORE

The electricity market can be seen as consisting of a wholesale market and a retail market, although these can overlap. The wholesale market deals with the trading of electricity-related commodities within a “real-time” or spot market with a supporting bilateral contracts market. The wholesale market therefore deals with the relationship principally between generators of electricity and wholesale buyers⁸ through the intermediary of a market operator. Retail market intermediaries, such as retailers buy from the wholesale market and sell or supply to consumers. The MSSL is such a retail market intermediary. Retailers can also access the wholesale market through the MSSL.

The institutions in the Singapore market are shown in Figure 2. These will be discussed in detail through the rest of this document. There are a number of different relationships between the entities participating in the markets, such as those relating to electricity flow, contractual and financial responsibilities. Figure 2 shows the financial flows for the supply of both electricity and services between the entities⁹.

**Figure 2: Schematic Diagram of NEMS
(Showing Financial Flows)**



⁸ Wholesale buyers can be large consumers, retailers and, in the case of Singapore, the market support services licensee.

⁹ It excludes bilateral contracts, other than vesting contracts, for simplicity.

4. Overview of the national Electricity Market of Singapore...

The key players in the NEMS are:

- *The regulator:* The EMA is the Regulator of the electricity sector and has the ultimate responsibility for ensuring that the NEMS meets the needs of Singapore.
- *The market operator:* The EMC is the company that operates and administers the wholesale market.
- *The power system operator:* The PSO, which is a division of EMA, is responsible for ensuring the reliable supply of electricity to consumers and the secure operation of the power system. The PSO controls the dispatch of facilities in the wholesale market, coordinates outage and emergency planning and directs the operation of the Singapore high-voltage transmission system under the terms of an “operating agreement” with SP PowerAssets, the transmission licensee.
- *The transmission licensee:* SP PowerAssets owns and is responsible for the operation and maintenance of the transmission system (comprising high voltage and low voltage networks).
- *Generation licensees:* All dispatchable generators of 10MW or above must be licensed by the EMA and are required to be registered with the EMC as market participants. Mandatory participation ensures that all generators of any significant size are subject to the market rules.
- *Market support services licensees:* MSSLs provide market support services such as meter reading and meter data management. They also facilitate access to the wholesale market for contestable consumers and retailers, and are responsible for supplying electricity to all non-contestable consumers. At the start of the NEMS, the incumbent supplier, SP Services Ltd, was the only MSSL, although others may enter the market at a later date.
- *Retail electricity licensees:* Retailers are permitted to sell electricity to contestable consumers. They may be MPRs and obtain electricity for this purpose by purchasing directly from the wholesale market (provided that they are licensed by the EMA to trade in the wholesale market and are registered with the EMC as market participants) or NMPRs and obtain supply through the MSSL.
- *Consumers:* Consumers are categorised as contestable and non-contestable, depending on their annual electricity usage. Contestable consumers may purchase electricity from a retailer, directly from the wholesale market (provided that they are licensed by the EMA to trade in the wholesale market and are registered with the EMC as market participants) or from the wholesale market indirectly through a MSSL. Non-contestable consumers are supplied with electricity by a MSSL.

4. Overview of the national Electricity Market of Singapore...

In the NEMS, among the rules governing permitted relationships are the following:¹⁰

- Transmission licensees and MSSSLs are not permitted to trade¹¹ in the wholesale market or to conduct competitive activities (retail and generation) or to own entities that conduct such activities.
- Generation licensees may trade in the wholesale market (as buyers or sellers) and may own a retailer, but are not permitted to conduct monopoly (transmission and market support services) activities or own entities that conduct such activities.
- Retail electricity licensees may trade in the wholesale market or obtain supply from a MSSSL and may import electricity, but are not permitted to conduct monopolistic activities (transmission and market support services) or own entities that conduct such activities.
- Contestable consumers may choose to purchase electricity from a retailer of their choice, directly from the wholesale market, or from the wholesale market indirectly through a MSSSL.
- All other consumers (referred to as non-contestable) are required to obtain supply from the MSSSL.

4.2 OVERVIEW OF THE WHOLESALE ELECTRICITY MARKET

This section briefly introduces the wholesale electricity market. More details are given in section 9.

4.2.1 Design Principles of the Wholesale Electricity Market

In a competitive electricity market, prices are used to determine the dispatch of electricity. This is in contrast to traditional centrally planned systems where the system control centre determines dispatch according to the efficiency of power plants and other technical considerations.

The Singapore wholesale market is designed for all parties involved to operate with confidence, based on principles that would ensure effective operation and reduce risk to market participants and the public. Specifically, the design principles are:

- *Robustness.* The market must perform reliably and consistently under a wide range of operating conditions.
- *Transparency.* Market participants and external observers must be able to see how the market operates, so that they can be certain that the market outcomes are appropriate.
- *Equity and fairness.* The market must provide a “level playing field”, offering equal and open access for all parties who wish to participate in it and that meet the requirements for wholesale market participation. For example, all new investment, including expansion of existing capacity, is treated on an equal footing: incumbents cannot be given any special consideration over new entrants, or vice versa.

¹⁰ The following description is based in part on the provisions of the Electricity Act and in part on provisions relating to cross-ownership that may be included in the electricity licences to be issued by the EMA under the Electricity Act.

¹¹ The MSSSL, of course, purchases its energy from the wholesale market.

4. Overview of the national Electricity Market of Singapore...

- *Minimise transaction costs.* Unnecessary transaction costs are to be avoided. This means that each design principle will be applied to the extent that the long-term gains outweigh the costs of giving effect to the principle.

4.2.2 Dispatch of Electricity

In the NEMS, the real-time dispatch of electricity (scheduling generators to supply energy, reserve¹² and regulation¹³) is determined by the operation of a wholesale spot market run every half-hour. Generators offer their capacity (specifying price/quantity pairs) into the market and the PSO provides a prediction of the expected load along with any system constraints for that half-hour. The market then determines the least-cost dispatch quantities and the corresponding market clearing prices based on the offers made by generators. This results in a dispatch schedule that is at minimum cost to the market while respecting transmission and system conditions and constraints, reserve and regulation requirements and the dynamic characteristics of generation plant and meeting the projected load at each node on the transmission system.

4.2.3 Market Prices for Energy

The wholesale spot market prices reflect the least-cost market solution to the dispatch of energy and the provision of reserve and regulation. In general, this means that each generator that submitted an offer below the market price will be dispatched and a generator that submitted an offer above the market price will not be dispatched. The market price for energy that dispatchable generators receive is a nodal price, which may vary according to the location on the network of the node to which the dispatchable generator has been assigned.

Buyers in the wholesale energy market pay the USEP for energy. This is a weighted average of the nodal prices at all of the off-take nodes in each half-hour.

4.2.4 Reserve and Regulation Markets

The NEMS schedules the provision of reserve and regulation simultaneously with the dispatch of energy based on offers received from market participants. Since generators that make plant available for the provision of regulation and reserve are forgoing energy production, the NEMS has reserve and regulation markets into which generators can offer capacity and for which they will be compensated.

The spot market price for regulation and each class of reserve is cleared along with that for energy. The regulation and reserve prices are common throughout Singapore but may vary according to the reserve class¹⁴ and reserve group¹⁵ to which the facility belongs.

¹² Reserve capacity is unused capacity that is available on a stand-by basis to supply energy in an emergency. Typically, this capacity must be able to be in production within a timeframe ranging from a few seconds to a few minutes, depending on the arrangement. It is often called spinning reserve to indicate that the turbines are already operating (literally, they are spinning) and can be activated to produce energy very quickly. Interruptible load is also a form of reserve.

¹³ Regulation, in this context, is generation capacity that is able to follow the normal variations in load during the half-hour dispatch period.

¹⁴ Reserve classes are discussed in section 9.5.1.

¹⁵ Reserve groups are groups of generators/loads with particular characteristics which are defined by the PSO

4.2.5 Prudential Requirements and Security Standards

The NEMS has prudential requirements and security standards that reflect the nature of the market and the manner of dispatch that must be respected. The security standards reflect Singapore's integrated electrical network that relies on generators to produce power in accordance with their offers. The prudential requirements ensure that market participants are able to meet their financial obligations to the wholesale market and are designed to protect the industry from defaults in payment.¹⁶ Metering standards ensure that injections and withdrawals of energy can be accurately metered every half-hour.¹⁷

4.2.6 Market Outlook, Pre-Dispatch Scenarios and Short-Term Schedules

Prior to each half-hour dispatch period, a series of indicative market and pre-dispatch scenarios are run to indicate the likely load and supply levels in that dispatch period. The indicative scenarios help to ensure that market participants have good information upon which to infer expected supply and demand conditions. This in turn allows dispatchable generators to offer efficiently and reduce their risks. Daily market outlook scenarios covering the beginning of the day D-5 to the end of day D, are prepared and provided to market participants on day D-6. Commencing on the day before the dispatch period, pre-dispatch market scenarios are prepared every two hours through to the actual dispatch period.

Short-term Schedules are also provided to market participants just after the start of each dispatch period. The Short-term Schedule covers the next 12 dispatch periods.

4.2.7 Bilateral Contracts and Vesting Contracts

In addition to trading in the spot market, participants can enter into bilateral contracts. These are purely financial arrangements whereby participants buy and sell on the spot market and settle between themselves any financial difference implied by their bilateral contracts. Such contracts create price certainty for the parties and limit their exposure to spot market volatility. Bilateral contracts do not affect dispatch (except indirectly through generator offer patterns) or pricing in the spot market, although the parties may choose to use the EMC's settlement system to settle the financial differences under their contracts.

Vesting contracts are a form of bilateral contract imposed on generators by the EMA for a transitional period. These contracts are a means of curbing the exercise of market power by the larger incumbent generators. The MSSL is the counterparty to all of the vesting contracts, which are settled between the MSSL and generators through the EMC's settlement system. The MSSL then settles vesting contracts with consumers or their retailer.

¹⁶ Under the market rules, a shortfall in funds resulting from a default in payment by a market participant is required to be satisfied by all non-defaulting market participants (excluding the transmission licensee). The prudential requirements have been designed to require the deposit of security to cover outstanding amounts so as to minimize the likelihood of payment default and the need to recover from the rest of the marketplace any shortfall created by the default.

¹⁷ The market rules contain the prudential requirements provisions as well as provisions relating to security standards that must be met by the PSO and technical requirements that must be met by market participant facilities. Additional technical requirements for facilities connected to the transmission system are contained in the Transmission Code. The majority of the requirements relating to metering are contained in the Metering Code.

4.3 OVERVIEW OF THE RETAIL ELECTRICITY MARKET

Until 2001, Singapore had a single electricity retailer or supplier (SP Services Ltd) that supplied all consumers. In order to gain efficiency benefits beyond those expected from a fully competitive wholesale market, retail competition is also being introduced.

Like many other competitive electricity markets, retail competition in Singapore is being introduced progressively. Large-volume electricity consumers became contestable first.¹⁸ The consumption volume threshold for contestability has been lowered over time. This would allow further opening of the market to consumers to occur smoothly without undue technical demands being placed on the retail companies, while allowing smaller consumers the benefit of additional time to learn about and understand their options in the new retail market.

By default, all non-contestable consumers and all contestable consumers that elect not to select a retailer or purchase from the wholesale market are supplied by SP Services Ltd, the MSSL. SP Services Ltd is required, under its MSS licence, to also provide contestable consumers who do not, cannot or no longer wish to purchase electricity from a retailer or directly from the wholesale market, the service to purchase electricity through SP Services Ltd at prevailing market prices.

While SP Services Ltd is permitted to supply contestable consumers, it may not participate in or own generation. SP PowerAssets is also prohibited from participating in retail activities or owning a retailer (as well as participating in or owning generation). This ensures that retailers can compete on an equal footing using the same network.

¹⁸ Large consumers that meet the prudential and technical requirements necessary for registration with the EMC as market participants are also able to purchase electricity directly from the wholesale market.

5. MARKET REGULATION

This section outlines the various rules, legislation, codes of practice, licences, manuals and agreements that will regulate the NEMS. All these are part of the regulatory regime that the respective market participants will be required to comply with.

5.1 GOVERNING DOCUMENTS

5.1.1 The Electricity Act

This is the principal legislation governing the electricity sector and the NEMS.

In addition, the rights and obligations of the participants in the wholesale and retail markets are set out principally in the wholesale market rules, and in the electricity licences and codes of practice issued by the EMA.

5.1.2 The Singapore Wholesale Market Rules

The wholesale market rules have the effect of a contract between each market participant and the EMC.¹⁹ This ensures that market participants have the recourse to take legal action against the EMC for damages sustained as a result of the non-observance of the market rules by the EMC and vice versa.²⁰ But the rules also contain dispute resolution procedures to be used in the first instance. Similarly, as a condition of registration as a market participant, each applicant will be required to enter into a contract with the PSO. This has the same objective and effect as the contract that is deemed to exist between the EMC and each market participant.

The objectives of the market rules²¹ are:

- To establish and govern efficient, competitive and reliable markets for the wholesale selling and buying of electricity and ancillary services in Singapore;
- To provide market participants and MSSL²² with non-discriminatory access to the transmission system;
- To facilitate competition in the generation of electricity; and
- To protect the interests of consumers with respect to prices, and the reliability and quality of electricity service.

¹⁹ Section 49 of the Electricity Act.

²⁰ The market rules do, however, contain provisions that limit liability and that address “force majeure” situations.

²¹ Section 3.1 of Chapter 1 of the Market Rules.

²² It should be noted that although the MSSL is obtaining supply from the wholesale market, it is not technically a market participant. However, the market rules provide for MSSL to be treated, for the most part, similarly to the manner in which market participants are treated. Thus, a MSSL is subject to most of the same obligations as market participants are under the market rules.

5.1.3 Electricity Licences

Under the Electricity Act, an entity may not engage in certain electricity-related activities unless it has been issued an electricity licence by the EMA (or it is exempted from holding a licence). The activities that require an electricity licence are:

- Operation of any wholesale electricity market;
- Generation of electricity;
- Transmission of electricity;
- Provision of market support services;
- Retailing electricity;
- Trading in the wholesale electricity market; and
- Importing or exporting electricity.²³

Holding of an electricity licence is not sufficient to actively trade in the wholesale market, as the following conditions must also be met:

- Participation in the wholesale markets for energy, regulation and reserve requires that the person²⁴ also register with the EMC as a market participant.
- In addition, certain facilities of the market participants are required to be registered with the EMC under a separate but mandatory process.

5.1.4 Codes of Practice

The electricity licences require the licensees to comply with one or more specified codes of practice²⁵. The codes of practice contain the detailed rules that govern the electricity licensees in conducting their licensed activities. The codes of practice developed to date are:

A. TRANSMISSION CODE

- This code is binding on SP PowerAssets, the transmission licensee. It sets the minimum conditions that SP PowerAssets must meet in carrying out its obligations as the provider of transmission services, and to facilitate non-discriminatory access to the transmission system.
- The code also (indirectly) binds persons whose facilities are connected to the transmission system through their connection agreements with SP PowerAssets. The connection agreements require the parties concerned to comply with their respective obligations under the Transmission Code.

²³ It is expected that the EMA will issue multi-activity competitive licences to generators and retailers that authorize not only the principle activity (i.e., generating or retailing) but also the activities of trading in the wholesale electricity market and where applicable, of importing and/or exporting electricity.

²⁴ Throughout this document we use the legal term “person” to mean an entity or organisation as well as of people in the normal sense. The context will usually be sufficient for the reader to gauge the usage.

²⁵ The applicable codes vary depending on the nature of the electricity licence.

5. Market Regulation...

B. REGULATED SUPPLY SERVICE CODE

- This code is binding on MSSSLs. It sets the minimum conditions that a MSSSL (such as SP Services Ltd) must meet in carrying out its obligations to procure the supply of electricity and provide market support services to non-contestable consumers under section 21 of the Electricity Act.

C. MARKET SUPPORT SERVICES CODE

- This code is also binding on MSSSLs. It sets the minimum conditions that a MSSSL must meet in carrying out its obligations to provide market support services to retailers and contestable consumers and facilitate their access to the wholesale market.

D. METERING CODE

- This code is binding on the transmission licensee, generation licensees and on MSSSLs. It sets out the minimum conditions that a metering equipment service provider must meet in carrying out its obligations to install and maintain meters. It also sets out the roles and obligations of the meter reader and meter data manager.

E. CODE OF CONDUCT FOR RETAIL ELECTRICITY LICENSEES

- This code of practice sets out the minimum standards of behaviour that a retail electricity licensee must observe in retailing to consumers.

5.1.5 Market and System Operation Manuals

Under the market rules, the EMC may issue market manuals and the PSO is required to produce a system operation manual. These lay out more detailed procedures and other requirements than are found in the market rules. Once adopted, the manuals are binding on the EMC, the PSO, all market participants and the MSSSLs.

Any market manuals prepared by the EMC must be reviewed by the rules change panel and approved by the EMA in order to have effect. The system operation manual is also required to be reviewed by the Rules Change Panel prior to taking effect.

5.1.6 Market Agreements and Contracts

In order to participate in the NEMS, most market entities are required to enter into a number of agreements and contracts. These are generally a consequence of their respective license conditions, the rules or codes. The various agreements are summarised below.

5. Market Regulation...

Agreement	Purpose
Generation Facility Operating Agreement (PSO – Gencos)	To establish a contractual relationship between PSO and Generation Licensee. This is to allow the PSO to dispatch Generation Licensee's generation facility(s).
MSSL – EMC Agreement	To make provisions in the Market Rules relating to MSSL, binding on MSSL and EMC. To establish the relationship between the EMC & MSSL as a contractual relationship. This agreement will incorporate the provision of meter reading services by MSSL to EMC for wholesale settlement.
MSSL – Market Participant Agreement (MSSL – Gencos / DMPs)	Provision of meter reading service of MPs meters for wholesale settlement. MP would pay directly for this service with fees set by MSSL.
PSO – Market Participant Agreement (PSO – Gencos / Retailers / DMPs)	To establish a contractual relationship between PSO and each market participant. To enable the parties to enforce obligations under the Market Rules.
PSO –EMC Agreement	Market rules contain requirements in relation to duties and responsibilities of EMC and PSO with respect to the other.
Market Support Services Agreement (MSSL – Retailers)	Services agreement between MSSL (as provider) and retailers (as procurers) of various customer support services as defined in the MSS Code.
Connection Agreement (SP PowerGrid, acting on behalf of SP PowerAssets – Gencos / DMPs / Customers)	To give effect to obligations that must exist between the party wanting connection service & SP PowerGrid, acting on behalf of SP PowerAssets.
Retailer Agreement (SP PowerAssets – Retailers)	Agreement between the SP PowerAssets and retailers for the collection of UoS charges when a retailer opts for consolidated billing (i.e. when the retailer assumes the payment responsibility of its consumers).
Agency Agreement (MSSL – SP PowerAssets)	Agency agreement for the provision of UoS collection services for SP PowerAssets.
Ancillary Services Agreement (Generators – EMC on behalf of PSO)	Contract between the EMC and offering generators for the supply of ancillary services (including reliability must-run, black start and reactive power).

6. THE MARKET INSTITUTIONS

This section describes the different entities in the NEMS and their various roles and inter-relationships - the regulator, the market operator, the power system operator, the market participants, the transmission company and the MSSL.

6.1 THE ENERGY MARKET AUTHORITY

The EMA is the Singapore Government agency in the gas and electricity market. It was formed partly to take over from the PUB as the regulator of the electricity industry. In addition, a division of the EMA is the Power System Operator for Singapore.

The regulatory powers of the EMA are provided under various statutes²⁶.

Specifically, under section 3 of the Electricity Act, the EMA is charged with the general administration of the Act and with exercising the following functions (among others):

- To protect the interests of consumers with regard to prices, reliability and quality of services;
- To perform the functions of economic and technical regulator;
- To ensure that electricity licensees provide an efficient service;
- To ensure security of supply of electricity to consumers and to arrange for the secure operation of the transmission system;
- To protect the public from dangers arising from electricity-related activities;
- To create an economic and regulatory framework for the electricity sector that promotes competitive, fair and efficient market conduct and prevents the misuse of monopoly or market power; and
- To advise the Government on matters relating to the electricity system.

In fulfilling these functions, the EMA has at its disposal a number of regulatory tools and powers. These include the authority to issue, suspend, revoke or modify an electricity licence; the power to issue and modify codes of practice and other standards of performance; the power to issue directions to electricity licensees; the power to fine electricity licensees; and the authority to investigate and sanction anti-competitive conduct.

It is intended that the EMA is self-funding from licence fees.

6.2 THE ENERGY MARKET COMPANY

The market company is the EMC, a company jointly owned by the EMA (with 51% shareholding), and M-co (The Marketplace Company) Pte Ltd (49%), a wholly-owned subsidiary of M-Co International Ltd from New Zealand. The EMC is licensed to operate the wholesale market.

²⁶ The Energy Market Authority of Singapore Act, along with the Electricity Act, Gas Act, and District Cooling Act.

6. The Market Institutions...

The EMC's functions are to:

- Operate and administer the wholesale market;
- Prepare schedules for generating units, loads and the transmission system;
- Settle accounts of market participants;
- Facilitate the planning and augmentation of the transmission system;
- Provide information and other services to facilitate decisions for investment and the use of resources in the electricity industry; and
- Exercise and perform the functions, powers and duties assigned to the EMC under the Electricity Act, its electricity licence, the market rules and applicable codes of practice.

Under the market rules, some of the EMC's functions are required to be carried out by persons, panels or committees appointed by the EMC. These are briefly described below and in greater detail in section 8.

6.2.1 Energy Market Company Board

A board of directors, referred to as the "EMC Board", oversees the EMC. The market rules assign certain functions, powers and duties specifically to the EMC Board and prohibit it from assigning or delegating them. These include voting on rule changes.

6.2.2 Dispute Resolution Counsellor and Dispute Resolution Panels

The dispute resolution counsellor is responsible for managing the dispute resolution process described in the market rules and for facilitating the resolution of individual disputes. The dispute resolution counsellor is also responsible for selecting a group of people onto a roster from which persons may then be selected to form a dispute resolution panel in respect of individual disputes. The dispute resolution counsellor is appointed by the EMC Board and is required to act independently of the marketplace.

6.2.3 Rules Change Panel

The principal tasks of the rules change panel are:

- To review any proposed changes to the market rules (including any changes that it may itself have proposed) and to provide recommendations in this regard to the EMC Board,
- To review proposed market manuals and the system operation manual, and any changes to them, and
- To review the EMC's and PSO's budgets and fees.

6.2.4 Market Surveillance and Compliance Panel

The market surveillance and compliance panel is an external panel established by the EMC Board to monitor the conduct of market participants and MSSs in the wholesale market and the structure and performance of the wholesale electricity market itself. It is assisted by the EMC's internal market assessment unit.

6.3 THE POWER SYSTEM OPERATOR

The role of the PSO (a division of EMA) is to ensure the security of supply of electricity to consumers and to arrange for the secure operation of the power system²⁷. The functions of the PSO include:

- Maintaining the reliability of the power system;
- Forecasting and reporting on conditions on the transmission system;
- Co-ordinating the outage of facilities;
- Providing network status and load forecasting to the EMC for the purposes of market clearing;
- Co-ordinating the actions of the EMC and market participants during emergencies; and
- Dispatching facilities.

In fulfilling its responsibility for maintaining the reliability of the power system, the PSO will direct the operation of the generation / transmission system under an "operating agreement" with Gencos / SP PowerAssets, the transmission licensee.

6.4 MARKET PARTICIPANTS

A market participant is a person that:

1. has an electricity licence, issued by the EMA or has been exempted from the requirement to hold an electricity licence; and
2. has been registered with the EMC as a market participant.

The wholesale market is a compulsory (or mandatory) market in the sense that any person who wishes to convey electricity over the transmission system must be registered as a market participant with the EMC.

Market participants may be²⁸:

- The transmission licensee;
- Generation licensees;
- Retail electricity licensees;
- Persons, other than generation licensees and retail electricity licensees, who have been licensed to trade in the wholesale market. (These are expected to be predominantly large contestable consumers but could also be wholesale traders.); and
- Any department of the Government which generates electricity before 1 Apr 2001.

However, a MSSL is not a market participant

²⁷ Subsection 3(3)(e) of the Electricity Act, and Chapter 1 section 5.1 of the market rules.

²⁸ Chapter 2, Section 2 of the Market Rules.

6.4.1 Generators

In the NEMS, it is generally mandatory for all generators of 10 MW or more to be licensed. Generators of below 10MW at a single location are generally exempted from licensing as a generator and are licensed only as a wholesaler.

It is also generally mandatory for multiple generating units with aggregate capacity of 10MW or more within a generating station be subjected to central dispatch, and for the relevant facilities to be registered as dispatchable facilities with the EMC.²⁹ Generators of 1MW or more but less than 10MW have the option of being either dispatchable or not. If not dispatchable, their facilities need only be registered as "generation settlement facilities" for settlement purposes. By making market participation mandatory for all but the smallest generators ensures that all generators are subject to the market rules and most are included in the dispatch process, and they pay their share of system and market costs, such as reserve and regulation charges.

A generator that participates in the wholesale market must comply with several licensing and registration steps:

- Licence with the EMA as a generator and as a wholesaler;
- Register with the EMC as a market participant;
- Enter into a connection agreement with SP PowerGrid, which acts on behalf of SP PowerAssets; and
- Where the facility is required to be or chooses to be dispatchable, registering the generation facility with the EMC as a "generation registered facility".

The requirement that a facility, which is not to be dispatchable, have still to be registered with EMC as a "generation settlement facility" is primarily to ensure that the facility has adequate metering in place to permit settlement.

Generators, like all market participants, must satisfy the prudential requirements set out in the market rules to ensure that they have the ability to meet all financial obligations arising from any transactions they undertake in the market³⁰. These are discussed in section 6.4.2.

6.4.2 Retailers

Contestable consumers are entitled to purchase electricity from the wholesale market, from a retailer of their choice or from the market support services licensee, SP Services Ltd.³¹ The retailer itself may also purchase directly from the wholesale market if registered as a market participant, or may obtain supply through the MSSL.

²⁹ As noted below, the process of registration of market participants is separate from the process of registration of facilities under the market rules since not all market participants will be participating in the markets through facilities and some licensees may not yet own facilities.

³⁰ Since generators are usually sellers, their prudential obligation will often be zero or negligible. Generators that conduct their transactions under bilateral contracts that are settled through the EMC settlement system may, however, have prudential obligations that are higher.

³¹ By contrast, non-contestable consumers must obtain their supply of electricity from SP Services Pte Ltd.

6. The Market Institutions...

When a contestable consumer transfers to a retailer, it pays for energy at the price agreed in their contract. The retailer may also offer the consumer other services, including billing and collecting of transmission charges payable by the consumer.

Where a retailer is registered as a market participant, it must meet the prudential and other requirements for market participation. For a MPR the prudential obligations are particularly significant.

The prudential requirements provide for:

- The nature of the credit support that must be provided and maintained by each market participant;
- The manner in which the amount of credit support is determined; and
- The EMC's responsibilities:
 - in monitoring transactions to ensure that the credit support provided remains adequate, and;
 - of issuing margin calls where it is contemplated that the credit support will become insufficient.

The prudential requirements serve to protect the marketplace from the effects of a default in payment by a market participant.

Where there has been a default in payment, all non-defaulting market participants (excluding the transmission licensee) are required to contribute on a pro-rata basis to cover the shortfall. This is done through the imposition of a "default levy" by the EMC.

6.4.3 Other Traders

At the commencement of the NEMS, no other traders except the generators, retailers and the MSSL traded in the wholesale market. The market rules, however, accommodate participation by other persons who are licensed to trade and meet the prudential and other requirements for registration as market participants. These would include large contestable consumers who wish to purchase directly from the wholesale market or to provide reserve to the wholesale market. These also include load aggregators and brokers. There are now 3 companies licensed to provide interruptible load services at NEMS.

6.5 THE TRANSMISSION COMPANY

The transmission network transports electricity at high voltage from generators to the low voltage distribution network (or, in a small number of cases, directly to large industrial consumers). PowerGrid has historically owned all of the network assets in Singapore.

PowerGrid was restructured in Oct 03 to form an asset company i.e. SP PowerAssets which owns the network assets in Singapore and a management company i.e. SP PowerGrid which serves as SP PowerAssets' agent to manage and operate the electricity network.

SP PowerAssets, being the monopoly provider of transmission services, is not permitted to compete in the energy market, whether as a generator, retailer or trader (either directly or indirectly by ownership of companies engaged in such activities), because opportunities exist for it to afford a preference to its competitive activities or its competitive affiliates.

6. The Market Institutions...

As a Transmission Licensee, SP PowerAssets is responsible for the operation and maintenance of the transmission system and, in the foreseeable future, for system planning and expansion. The Transmission Code requires:

- SP PowerAssets to make physical connections and disconnections and, in the case of consumers, to provide and install metering systems.
- SP PowerAssets and persons whose facilities are connected to the transmission system to have technically sound equipment and for equipment to be operated within its ratings.
- SP PowerAssets to plan network maintenance and outages.
- SP PowerAssets to expand, enhance, upgrade, replace and reconfigure parts of the network as appropriate.

The responsibilities of SP PowerAssets and of persons whose facilities are connected to the network are set out principally in the Transmission Code and related connection agreements. The market rules also contain provisions relating more specifically to the obligations of SP PowerAssets and the PSO in respect of the reliability and security of the transmission system.

Any person whose facilities are directly connected to the transmission system is required to enter into a connection agreement with SP PowerGrid, which acts on behalf of SP PowerAssets. The connection agreement also contains provisions relating to the provision of and payment for transmission services to such facilities through a connection charge.

Consumers and retailers who intend to bill their customers for transmission charges are, for their part, required to pay a use-of-system charge to SP PowerAssets for the provision of transmission services. Charges for transmission services are regulated by the EMA.

The MSSL calculates, bills for and collects transmission charges on behalf of SP PowerAssets.

6.6 THE MARKET SUPPORT SERVICES LICENSEE

At present, SP Services Ltd is the sole MSSL, and is required, as such, to provide the following market support services to various parties:

- Reading electricity meters and managing the data relating to meter reading;
- Facilitating access to the wholesale electricity market for contestable consumers and retail electricity licensees;
- Facilitating the transfer of contestable consumers between retailers; and
- Supplying electricity to non-contestable consumers.

SP Services Ltd represented the majority of consumers in Singapore at the commencement of the NEMS. As a monopoly supplier, SP Services Ltd charges regulated fees (approved by EMA) on its customers for market support services provided.

The MSSL has a specific role in the settlement of vesting contracts. The MSSL is the counterparty to the generators for vesting contracts and will calculate and settle vesting contracts with consumers or their retailers. This role is explained in more detail in section 8.

6.7 ELECTRICITY FINANCIAL AND SERVICE FLOWS

In summary, the NEMS is characterized by several “flows” – electricity financial flows, and flows of service as follows:

- *Electricity Flows.*
 - Electricity flows from generators via the transmission system to load (i.e. consumers)
 - Generators are dispatched by the PSO in accordance with real-time dispatch schedules produced by the MCE
- *Financial Flows.*
 - The wholesale market pays each generator for the energy it injects into the transmission system.
 - The wholesale market pays for ancillary services obtained from dispatchable generators and interruptible load. Where the ancillary service is obtained under contract rather than obtained from the market, payment is made in accordance with the terms of the contract.
 - MPRs (i.e. those who obtain supply from the wholesale market), market-participant consumers (i.e. contestable consumers) and MSSLs pay the wholesale market for their withdrawals of energy from the transmission system.
 - NMPPRs pay the MSSL for market support services as well as their withdrawals of energy from the transmission system.
 - A market participant may choose to settle amounts owing under its bilateral contract with another market participant either through the EMC's settlement system, or directly with their contracting party.
 - Contestable consumers pay their retailer (if they have chosen a retailer) or SP Services Ltd (if they have not chosen a retailer) for electricity consumed.
 - Non-contestable consumers pay SP Services Ltd for electricity consumed.
 - Consumers and retailers (on behalf of their customers) pay SP PowerAssets for transmission services provided, which is initially collected by the MSSL on behalf of SP PowerAssets.
 - Market participants pay to the EMC, PSO and the MSSL the fees determined or approved by the EMA.
 - MSSL charges for services it provides, generally on a fee for service basis, as approved by the EMA.
- *Flows of Services*
 - Generators provide energy
 - SP PowerAssets provides connection and access to the transmission system, including wholesale-level meters (except generators, who supply and install their own).
 - EMC provides wholesale market clearing and settlement services, including a facility whereby amounts owing under bilateral contracts can be settled through the EMC's settlement system.
 - EMC provides the services of a dispute resolution counsellor for settlement of disputes arising in the wholesale market.

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- MSSL supplies electricity and provides related metering services to all non-contestable consumers.
- MSSL provides metering services to the EMC and to all market participants who have facilities directly connected to the transmission system.
- MSSL provides related metering services to all contestable consumers. It is also required under its MSS licence, to provide a contestable consumer who does not wish to purchase electricity from a retailer or wholesale market, the service to purchase electricity at prevailing market prices.
- MSSL acts (at least initially) as the agent for SP PowerAssets in respect of the calculation, billing and collection of transmission charges.
- MSSL provides customer transfer services for transfers among MSSL, retailers and wholesale market.
- Market participants provide ancillary services to the wholesale market.

7. MARKET ADMINISTRATION AND SUPERVISION

This section describes in greater detail the more significant administrative provisions of the market rules relating to dispute resolution, market surveillance, rule changes, enforcement and market suspension.

7.1 DISPUTE RESOLUTION

A comprehensive and flexible dispute resolution procedure is set out in the market rules.

Use of this dispute resolution procedure is mandatory (with a few exceptions) for:

- Disputes between the EMC or the PSO, on the one hand, and a market participant or MSSL, on the other hand, for disputes arising under the market rules, a market manual or the system operation manual or under any agreement or contract referred to in those documents;
- Disputes arising from the denial by the EMC of registration as a market participant; and
- Disputes relating to compensation payable by the EMC or the PSO under those sections of the market rules that expressly allow for the payment of compensation.

The EMC Board is required to appoint a dispute resolution counsellor to oversee and manage the dispute resolution process under the market rules and to facilitate the resolution of disputes.

The dispute resolution counsellor is also responsible for appointing qualified persons to a mediation panel and an arbitration panel. These panels collectively called a dispute resolution and compensation panel are used in resolving disputes through mediation for mediation panels and arbitration for arbitration panels. There are strict selection and eligibility criteria for both the dispute resolution counsellor and those appointed to a dispute resolution and compensation panel.

7.1.1 Dispute Resolution Procedure

The dispute resolution procedure is generally as follows:

- The parties must first attempt to amicably resolve the dispute through their respective internal dispute management systems. These internal systems are required to be established by the EMC, the PSO, each market participant and each MSSL. They are designed to facilitate discussion and good faith negotiations during the initial stage of the dispute resolution process.
- If there is no amicable resolution of the matter, one party commences the more formal process by filing a notice of dispute with the dispute resolution counsellor, who decides whether the dispute is eligible to be heard and notifies the parties accordingly.
- For the case where the dispute is eligible to be heard, unless the dispute resolution counsellor determines that mediation is not an appropriate means for resolving the dispute, the dispute resolution counsellor selects a person (the “mediator”) from the mediation panel to mediate the dispute.
- If the dispute resolution counsellor determines that mediation is not an appropriate means for resolving the dispute or the dispute is not resolved after a mediation

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session has been attended or is not resolved within a stipulated timeframe, the dispute would move to arbitration.

- One or three persons are appointed from the arbitration panel by the disputing parties to form the arbitration tribunal. If the disputing parties fail to select an arbitration tribunal, the dispute resolution counsellor shall select one. The dispute resolution and compensation panel consults all parties in the dispute and gives them an adequate opportunity to present their case. It may also consult any other person, other than EMC executive, management and staff, it sees fit³². It may require the parties to exchange submissions, documents and information.
- The dispute resolution and compensation panel may make whatever determination or award in respect of a dispute that it decides is just and reasonable, including damages in appropriate cases, subject to any limitations of liability that may be set out in the market rules.

A determination or award made by the disputes and compensation resolution panel is final and binding on the parties in the dispute and is not subject to appeal or review other than by appeal to a court in Singapore on a question of law or jurisdiction.

7.2 MARKET SURVEILLANCE AND COMPLIANCE PANEL

The market rules require that activities in the wholesale market and the conduct of market participants and MSSLs be monitored in order to:

- Identify breaches of the market rules, any market manual or system operation manual;
- Identify market flaws; and
- Assess whether the underlying structure of the market is consistent with the efficient and fair operation of a competitive market.

The monitoring activities are to be carried out by the EMC's internal market assessment unit, acting under the supervision and direction of the external market surveillance and compliance panel.

To carry out its assessment and surveillance function, the market assessment unit is required to develop an information system and evaluation criteria. This involves creating and periodically updating:

- A detailed catalogue of all of the data to be collected and used; and
- A catalogue of the monitoring indices that will be used to evaluate the data.

The market surveillance and compliance panel shall consist of at least three persons, having expertise in:

- The operation of competitive wholesale electricity markets or financial or commodity markets;
- Singapore laws and/or electricity regulations
- Competition law and policy;
- Power system operations; or

³² Consultation with staff, management and executive of the EMC requires the consent of the parties.

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- Economics.

The market surveillance and compliance panel and the market assessment unit both have monitoring and reporting functions while the market surveillance and compliance panel also has an investigation function.

7.2.1 Regular Monitoring and Reporting

The market assessment unit monitors daily market behaviour in the wholesale market under the direction of the market surveillance and compliance panel.

The market assessment unit is required to make a report, at least quarterly, on its day-to-day monitoring and evaluation activities to the market surveillance and compliance panel. It is also required in the following cases to report:

- To the market surveillance and compliance panel, where it discovers evidence of phenomena that may require investigation or where it discovers the possible need for a change to the market rules or evidence that a market participant or MSSL or the EMC or the PSO may be breaching the market rules; and
- To EMA, where it receives any complaint or uncovers any information that may indicate the possibility of anti-competitive agreements or the abuse of a dominant position contrary to section 50 or 51 of the Electricity Act.³³

Similarly, the market surveillance and compliance panel is required to make a report, at least annually, to the EMC, giving an overview of its monitoring activities, a summary of all complaints, referrals and investigations, and any investigations it had conducted in respect of offer variations reported to it by the EMC.³⁴ The annual report must also contain the market surveillance and compliance panel's general assessment as to the state of competition and compliance within, and the efficiency of, the wholesale market.

7.2.2 Ad Hoc Investigations

The market surveillance and compliance panel may investigate any activities in the wholesale market, either at the request of a third party or on its own initiative.

When the market surveillance and compliance panel determines that a market participant, the EMC or the PSO has breached the market rules, it is required to provide a report, which should include the facts and circumstances of the breach and details of any sanctions imposed. The report is provided to the EMC and the EMC shall notify the EMA. Where the PSO is in breach, the report will be provided to the PSO and the EMA. Where the report does not contain confidential information, it will be published by the EMC. Where the report contains confidential information, an edited version will be prepared by EMC for publication.

Where the market surveillance and compliance panel finds that a modification to the market rules may be required, or that a market participant, a MSSL, the EMC or the PSO may be breaching the market rules, the panel shall initiate an investigation and may report any findings to the EMC, the PSO or the EMA.

³³ The market surveillance and compliance panel may do the reporting instead of the market assessment unit.

³⁴ Under the market rules, any offer variations for a dispatch period that are submitted within two hours of the commencement of the dispatch period are (they usually will be, but there are let offs) reported by the EMC to the market surveillance and compliance panel.

7.3 RULE CHANGES

In the NEMS, rule changes can be initiated by any interested party and are subject to approval by the EMA. Much of the rules change process is led by the rules change panel appointed by the EMC Board. The composition of the rules change panel, the transparency of the process and the need for final EMA approval are designed to provide assurance that the rule change process will not prejudice the operation of the market or unduly affect the interests of any particular participant or class of participants.

7.3.1 Rules Change Panel

The composition of the rules change panel is expected to comprise ³⁵:

- The Chief Executive of the EMC;
- One employee of the EMC other than the Chief Executive;
- One representative of the PSO;
- Three representatives of the generation licensee class of market participant;
- One representative of the transmission licensee class of market participant;
- Two representatives of the retail electricity licensee class of market participant;
- One representative of the wholesale electricity market trader class of market participant
- One representative of the MSSs;
- Two representatives of consumers of electricity in Singapore; and
- One representative of the financial community in Singapore.

7.3.2 Rules Change Procedure

A request for review of the market rules can come from any interested person, including the EMC Board and the rules change panel itself. They may propose modifications to the market rules or identify a rule where they consider a modification or review may be desirable.

The general rules change procedure is as follows:³⁶

- Prior to the rules change panel considering a modification submission, the EMC publishes an invitation to make written submissions to the rules change panel. The panel may hold public meetings.
- At the conclusion of its deliberations, the rules change panel submits a written report to the EMC Board indicating:
 - the recommendations (with reasons) of the rules change panel ;
 - a copy of the proposed text of the modification, if any;
 - a summary of any objections to the modification;

³⁵ Chapter 3 section 2.3 of the Market Rules

³⁶ The market rules also provide for expedited processes to address urgent rule changes.

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- whether the recommendations have the support of the dispute resolution counsellor or the market surveillance and compliance panel, if the modification affects a provision of the market rules that relates to their respective functions; and
- a record of the vote of each member of the panel on the recommendations and a summary of any objections raised by a member of the panel to the recommendations.
- The EMC publishes the proposed text of the modification, if any.
- The EMC Board then considers the recommendations of the rules change panel. The EMC Board may decide in favour of or against the proposed modification, or may refer the matter back to the rules change panel for reconsideration.
- Where the EMC Board decides against the proposed modification, it publishes the decision, together with an indication of the reasons for the decision. The EMC Board may only reject a proposed modification that has been recommended by the rules change panel on the grounds listed in the market rules.
- Where the EMC Board decides in favour of the adoption of a modification, it must:
 - publish the decision, together with a copy of the modification, and provide a copy to the PSO; and
 - file a copy of the decision, together with a copy of the modification, a copy of the associated report of the rules change panel and a summary of any objections to the modification brought to the attention of the EMC Board, with the EMA.

The EMC Board may adopt a modification to the market rules that has been rejected by the rules change panel only in the limited circumstances referred to in the market rules.

Finally, the rule change must be approved by the EMA, which may only reject it on specified grounds listed in the market rules.

7.4 MONITORING AND ENFORCEMENT OF THE MARKET RULES

The market assessment unit is responsible for monitoring the markets to ensure that market participants and MSSs comply with their obligations under the market rules and market manuals. The PSO is responsible for monitoring to ensure compliance with those parts of the market rules that related to its functions and duties and with the system operation manual.

Where a market participant or a MSSs or the EMC or the PSO breaches the rules, the market surveillance and compliance panel may sanction such non-compliance with:

- Fines (only against market participants, a MSSs or the EMC);
- Suspension from the market;
- Expulsion from the market;
- The revocation of the registration of a facility; or
- Notifying the EMA, who may take further actions

The market rules contain procedures that must be followed by the market surveillance and compliance panel in investigating and sanctioning non-compliance.

8. VESTING CONTRACTS

Vesting contracts have an important role in limiting market power and are also a way of limiting price risk for both generators and consumers. This section examines the role of vesting contracts in the NEMS.

8.1 VESTING CONTRACTS

When making the transition from a government-owned and centrally-controlled electricity system to a privately-owned and competitive system, several economic and public policy issues can arise. A major concern for the EMA in the transition to the NEMS is the market power of generators that exists in the wholesale market.

This concern is addressed using vesting contracts without interfering with the structure of the wholesale market. Vesting contracts are bilateral financial contracts imposed (vested) on certain market participants prior to the commencement of the market. In Singapore, the vesting contracts take the following form:

- They are between existing large generating companies (including generating companies already licensed when the decision was made to implement vesting contracts) and the MSSL as the agent for consumers as a whole. The MSSL will then distribute debits and credits associated with the contracts to the retailers, the non-contestable consumers and the contestable consumers who purchase electricity from the pool.
- They have a contract price (or strike price) set at about the economic cost (long-run marginal cost or LRMC) of a new entry generator³⁷. The same strike price applies to all generators.
- The contract quantity will be set to curb the exercise of market power of the big generators to an acceptable level and to encourage the spot market price not to average above LRMC. During peak load times, the contract quantity will be a larger proportion of total load, while in off-peak times; it will be a smaller proportion. The average contract quantity will reduce over time as demand grows or as new capacity is built to mitigate the market power of incumbents.
- The contract quantities for each generator are based on the generation capacity of each of the companies.
- The level of contract cover for the market exceeds the cover required for all non-contestable consumers. Thus having covered all the non-contestable consumption with vesting contracts, there are still some vesting contracts still to be assigned. This unassigned contract quantity will be allocated to contestable consumers.

³⁷ This is the electricity price that a new investor in base-load capacity would require in order to cover its fixed and variable costs at a reasonable return to shareholders over the life of the plant.

9. WHOLESALE MARKET OPERATION

This section elaborates on the operations of the wholesale market.

9.1 THE POWER SYSTEM OPERATOR

The Power System Operation Division³⁸ of EMA is responsible for the integrated operation of Singapore's generation and transmission system. The PSO's responsibility covers day-to-day operations, system security assessment and system emergency planning.

By evaluating the forecasted indicative scenarios, the PSO ensures that the dispatch schedules produced by the EMC do not compromise the security of the Singapore power system.

9.2 MARKET CLEARING – PRICING AND DISPATCH

9.2.1 Dispatch Scheduling

Dispatch scheduling is the process of anticipating the generation capacity needed to meet forecast demand. It is at the heart of running an electricity system. The PSO and the plant dispatch co-ordinators need to know in advance when each plant will be operating and how much output is expected from each. The dispatch schedule comes from the MCE and is thus feasible for the physical system, as well as optimal to the market³⁹.

The PSO instructs the generators to conform to the dispatch schedule. Any deviations from the estimated load and corresponding schedule are handled by the PSO using ancillary services.

9.2.2 The Market Clearing Engine

Every half-hour a computer model (called the MCE⁴⁰) is run to determine the dispatch schedule and the associated energy market prices for the up-coming dispatch period. In addition to the dispatch schedule and energy prices, MCE determines which plant is on reserve and regulation duty along with the market prices for reserve and regulation.

The objective of the MCE is to find a set of dispatch instructions that minimises the cost of supplying⁴¹ the load at all nodes, as well as meeting the reserve and regulation requirements. There is no overall cheaper dispatch available, in terms of the offers that have been made to the market, by providing energy, regulation or reserve from different suppliers or in different quantities from the same suppliers. This is the minimum cost market dispatch.

³⁸ Further information can be found at www.ema.gov.sg/Electricity/psod.php

³⁹ There may be many feasible dispatch schedules for the half-hour, but the MCE finds the optimal one - the least-cost set of offers for each of energy, regulation and reserve.

⁴⁰ The MCE is a linear programming model. As such it solves linear simultaneous equations to find the solution that best meets some criterion or "objective". All of the conditions stated in this section are specified as linear functions.

⁴¹ The cost of supply is measured by the generator offers, not their costs of production.

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The supply of energy, reserve and regulation is specified by means of offers that contain price/quantity tranches indicating the quantity of energy, reserve or regulation that each dispatchable generator is willing to supply at the corresponding energy, reserve or regulation prices. The offer process is discussed in detail in section 9.4.

The MCE takes into account constraints on the electricity system such as:

- The offers made by dispatchable generators;
- Estimated demand at each node on the network;
- Reserve and regulation requirements (including the offer made by interruptible load for reserve);
- The state of the power system at the commencement of the dispatch period (plant energy setting, transmission system availability, etc);
- The available capacity of plant;
- The rate at which plant can change their output (ramping rate);
- The relationship between energy production, reserve capacity and regulation capacity for each plant;
- Physical limitations on the flows that can occur on the transmission system⁴²;
- Losses (that vary with the configuration of, and power flows on, the power system); and
- Constraints in relation to system security.

The model is run with estimates of the demand for the coming dispatch period.

In addition to finding a dispatch schedule and regulation and reserve allocations, the MCE produces market prices that correspond with that solution.

With the dispatch based on estimates of the demand for the coming dispatch period, the market prices are similarly the prices set according to those estimates. This form of price setting, called *ex ante* pricing (pricing before the event), gives the market participants certainty about market prices even if dispatch quantities differ from those scheduled⁴³.

The MCE does not produce a single market energy price because of the effects of losses and congestion on the transmission system. Different energy prices apply to different nodes on the transmission system. However, as discussed in section 10.2.6, in the case of the price seen by load, these prices are averaged.

9.2.3 Market Clearing Process – An Example

Figure 3 shows a simplified example of how offers by dispatchable generators and total consumer demand interact to produce the market-clearing price in a specific half hour

⁴² To fit into the linear programming formulation of the model these are approximated as DC load-flow equations, although a simple adjustment is made for reactive power flows.

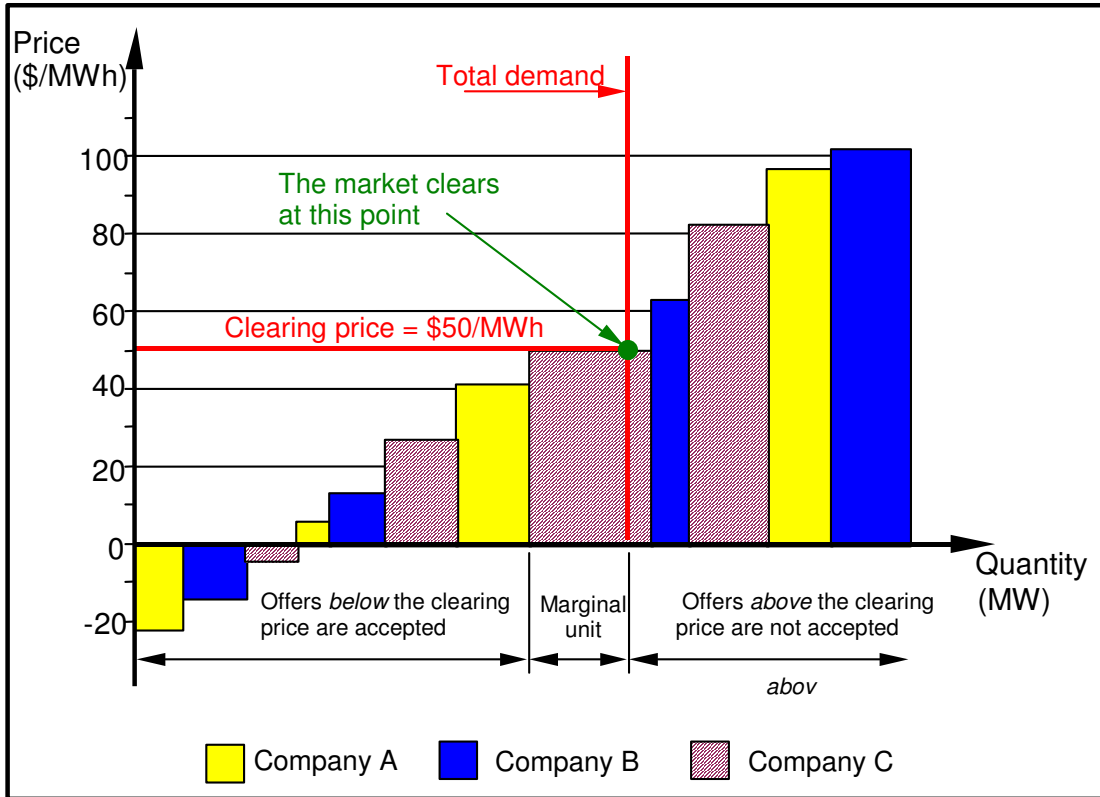
⁴³ For all but plant providing regulation, energy actually injected should not differ greatly from scheduled energy, under normal circumstances.

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(complicating factors such as plant ramping, transmission and system security constraints and reserve have been omitted).

In this example, there are three generators (A, B, and C) whose offers consist of four price/ quantity tranches each. The tranches are arranged in ascending price order. The market-clearing price is found at the point where total demand from consumers is met by the offer tranches. In this example, the third tranche from Company C sets the market-clearing price with its offer price of \$50/MWh. The total demand is a forecast of the load for that period.

Figure 3. Example Market Clearing Process



Offers below the market-clearing price are accepted and those generation units are dispatched to the full. Offers above the market-clearing price are not accepted, and so the generation capacity represented by those offers is not dispatched at all. At the margin, the offer that sets the price is usually only partially dispatched. This plant is called the marginal unit. There is always a marginal unit whose offer sets the market-clearing price.

In economic terms, the diagram shows a supply and demand curve. The supply curve is the stepped offer curve from generators and the demand curve is the forecast load. The market clearing price and dispatch schedule quantities are set by the intersection of the two curves.

Plant with tranches below the market clearing price make a profit equal to the difference between their offer and the market clearing price. This is the standard producer surplus of economics – the gain made by more efficient producers. Those producers who are not efficient enough to meet the market at the market-clearing price are not dispatched.

9.2.4 Unit Commitment

The NEMS is a self-commitment market. This means that unit commitment is the responsibility of each generation company and no start-up and shutdown payments are made (generators are expected to factor these into their offering strategy)⁴⁴. This fact is important because some generation units require a significant period of time to warm up before they can produce electricity and hence need to be committed some time in advance. The PSO needs to know and account for the ability of plant to ramp up or down. In the NEMS, this information is part of the standing capability data required from each facility.

9.2.5 Nodal Pricing

In common with many modern electricity markets, the NEMS uses a form of energy pricing referred to as nodal pricing, meaning that prices at each node in the network will be influenced by the physical properties and constraints of the transmission system. This results in the price of energy differing at different physical locations on the network. The MCE automatically produces a different price at each node on the network. Dispatchable generators are paid the nodal price at their point of injection.

The MCE clears the market at all of the nodes simultaneously and manages the power flows between nodes to ensure a dispatch schedule that is both physically feasible and economically efficient. The power flow on the transmission system is very complex and can create considerable difficulties for the management of dispatch. Nodal pricing will correct for this by pricing the energy at each node so that generally only those tranches of energy offered at, or below, the market price at their own node will be dispatched.

Nodal pricing differences can arise due to transmission losses, physical limitations on the transmission system, or interactions within the transmission system (loop-flow effects). These effects exist in any event and must be overcome when determining the dispatch schedule. Nodal prices place a value on the transmission effects. Market participants do not need to understand the detailed mechanisms by which such effects occur, but they can build up an understanding of the transmission system by merely observing the nodal prices over time.

In the short term, by responding to nodal prices, the market creates a dispatch schedule that optimises the use of the transmission system.

In the long term, nodal prices encourage the right investment decisions. Generators will build new capacity at high-price nodes, which should relieve some transmission congestion without resorting to new investment in transmission lines. When new transmission capacity is the proposed solution to congestion problems, nodal prices can help evaluate the alternatives in commercial terms. Nodal pricing is crucial to ensuring that accurate economic evaluations of engineering decisions can be made.

Although it is sometimes criticised as complex and unnecessary, nodal pricing adds little complexity for market participants. It simply means that the true costs to the market of delivering electricity to each point on the transmission system are revealed.

⁴⁴ An alternative arrangement is a “central commitment” market, wherein the system operator schedules start-ups and shutdowns. The Singapore Electricity Pool was a central commitment market.

9.2.6 Uniform Singapore Energy Price

In Singapore, while generators are paid their nodal price, buyers from the wholesale market pay a uniform overall average price so that no consumers are locationally disadvantaged. Because the Singapore transmission system is well developed and has few instances of constraints that will impact the nodal prices that would otherwise be faced by load, uniform pricing is an acceptable compromise between accurate economic signalling and social policy objectives.

To create a uniform price for buyers a USEP is calculated from the weighted average of the nodal prices over all of the nodes that withdraw energy. The nodal energy price at each node is weighted by the estimated energy demand from that node. In this way, the total price paid by all consumers under USEP is the same "total price would be if each consumer paid the price at its node."

The USEP is augmented by the uplift charge made by the EMC.

9.2.7 Accounting for Electrical Losses

As electricity flows through the transmission system, a small percentage of energy is lost in the form of heat, due to electrical resistance. The typical level of electrical losses on the Singapore network is about 1-2%. This means that if a customer requires a unit of electricity, generators will need to produce more energy than that to allow for the losses incurred in transporting the electricity from the generator to the customer. Electrical losses vary by location and over time, depending primarily on network characteristics and usage.

While nodal price differences account for some of the losses, the total paid to generators will usually be less than that collected from loads because of congestion and losses not fully accounted for in nodal prices⁴⁵. Consequently, in the settlement process, the EMC is paying out less to generators than it collects from loads. Import and export flows through the intertie with Malaysia also impact on the difference between what is paid to the generators and what is paid by load. The impact can be positive or negative depending on prices as well as whether there is net import or export. The EMC has to settle this difference. This is discussed under settlement surplus in section 10.2.

9.2.8 The Cost of Energy Shortage

Energy prices in the Singapore wholesale spot market are effectively uncapped most of the time. However, for computation purposes, the maximum price will be limited by the software to a specified large number, which reflects the cost of shortage if the system was somehow not able to satisfy the load. This price is called the "Value of Lost Load" (VoLL) or the "value of energy not served". The maximum price paid to generators is $0.9 \times \text{VoLL}$. Maximum price paid by consumers is more than that due to transmission losses but is effectively capped at VoLL.

When the system faces shortages through insufficient supply being offered into the market, the price paid to generators for those periods will go to $0.9 \times \text{VoLL}$ ⁴⁶. If this is

⁴⁵ The settlement surplus created by losses is because the loss function is approximately quadratic, not linear, so that the average loss (the difference in energy generated and consumed) is about half the marginal loss (the nodal price difference).

⁴⁶ There are several "shortage" prices, including those for reserve and regulation.

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observed in a pre-dispatch scenario, the 0.9 x VoLL price provides incentives for generators to make offers and hence enable demand to be met.

Allowing the price to go to a very high level for a few extreme dispatch periods is an important element in ensuring that there will continue to be adequate capacity during such periods in the future. Since peaking generation plants may only run infrequently, it is important that when they do run, they receive sufficient revenue to ensure their viability. If consumers wish to be protected from these extreme price events, they can “hedge” against them by entering into financial contracts with generators.

The market is designed to handle as many situations as possible within the market framework and to limit the need to suspend the operation of the market to extremely serious circumstances that are not related to pricing.

9.2.9 Reasons for Negative Energy Prices

Nodal energy prices in the Singapore market are allowed to become negative. Negative prices can occur in two ways, either directly through negative offers by generators offering energy into the market, or as a result of transmission loop-flow effects. They fulfil a useful economic and dispatch function by signalling to generators that they should back off their units, or perhaps even shut them down when there is an excess of energy in the system.

A generator making a negative offer is signalling that it wants to keep its plant running over a minimum load period (typically during the middle of the night, or if the plant is a cogeneration plant) and that the cost of shutting down is greater than the cost of continuing to run. Generators may wish to continue to be dispatched through this period so that they will have capacity available as soon as load increases. Naturally, a negative offer, or a series of negative offers, will (normally) only result in a negative market-clearing price if all offers by all generators needed to fulfil the load is negative⁴⁷. In this case the negative price is an important tool in managing the conflicting desires of generators in a fair and economically efficient manner.

Negative prices can also be caused by transmission constraints on the system. This is an extreme event caused by loop-flow effects⁴⁸. When it occurs, it indicates that a plant needs to be backed-off to relieve a transmission problem. The negative price provides the signal to the generator to do so. Currently, transmission constraints are unlikely to cause negative prices in the Singapore power system.

9.3 MARKET OPERATIONS TIMETABLE

As well as a real-time market, advance indicative market outlook and pre-dispatch scenarios are prepared to help with outage planning and real-time offering strategy and to indicate to consumers and retailers the expected prices they may face so that they can take remedial action. The indicative market scenarios are not binding and create no financial commitments.

⁴⁷ In markets where the market-clearing price has been negative, generators have quickly discovered that their plant can be operated more flexibly than they first believed.

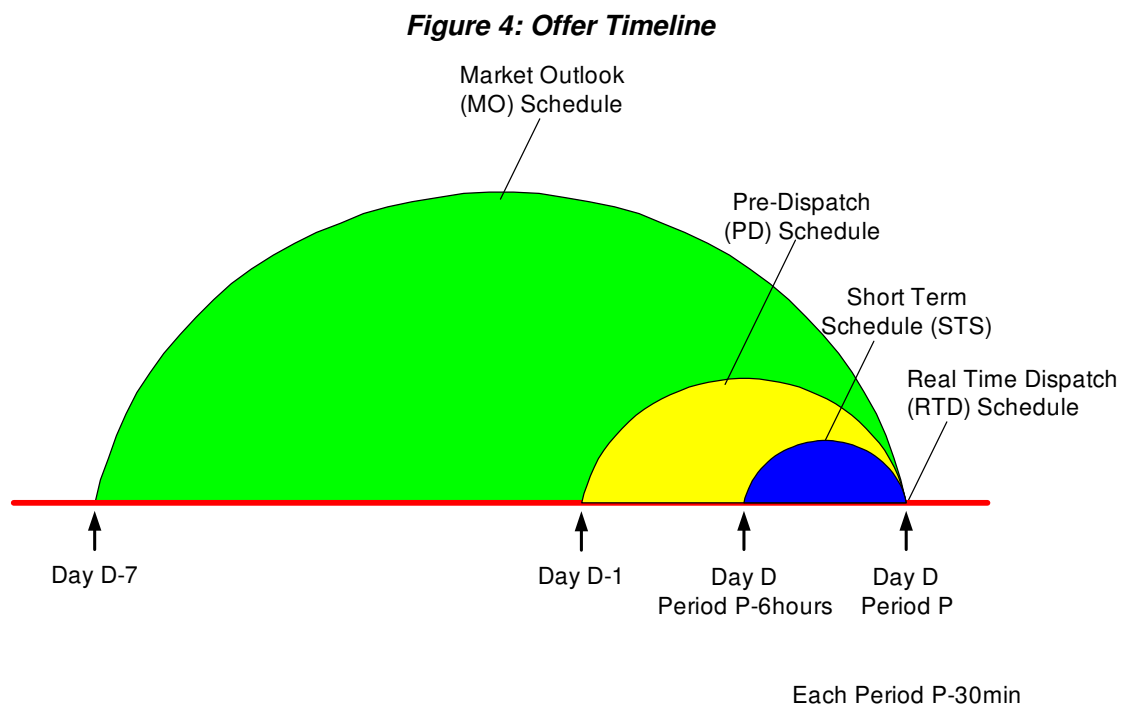
⁴⁸ Loop flows cause a phenomenon that is sometimes called the “spring washer” effect. The prices on either side of a transmission constraint are being pushed in opposite directions. If the change around the loop is sufficiently severe the nodal price on one side can go very high and/or the nodal price on the other side goes so low as to be negative.

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The two indicative advance scenarios are:

- *Market Outlook Scenarios* - six-day rolling horizon re-issued daily. Indicative pre-dispatch schedules and prices are issued for the next week.
- *Pre-dispatch Schedules* – 1 to 2 day horizon re-issued every two hours. Indicative pre-dispatch schedules and prices are issued for the current day and the next dispatch day.
- *Short-term Schedules* – issued every half hour covering the 12 dispatch periods after the dispatch period in which it was issued. Used for indicative purposes.

These are followed by the real-time dispatch, consisting of the real-time dispatch schedule (which is deemed to constitute the dispatch instructions for facilities) and market prices. At this point, generators are committed to their offer prices and quantities.



The key steps in the offer timeline are shown in Figure 4. These steps correspond to the 6-day market outlook scenarios, 1-2 day pre-dispatch scenarios and real-time timelines. Input Data Required for the Market to Operate

The same input data are required for each of the two indicative market scenarios, the short-term schedules and for the real-time dispatch:

- Capability data for all dispatchable plant: Standing capability data is provided when the plant is registered and may be revised in accordance with the system operation manual. These data state the characteristics of the plant, such as upper limits on ramping rates and maximum output capability, and data on the energy-reserve trade-off function.
- System data for the transmission network and security conditions: Standing data is supplied by the PSO and may be revised at any time.

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- Offers for energy, reserve and regulation for all dispatchable plant: Standing offers are provided when the plant is registered. Variations to offer data for a dispatch period can be submitted at any time after 0900hrs on day D -8, where the dispatch period is in day D, up to the gate closures described below.
- Load projections for each half-hour are provided by the PSO. These are on a Singapore-wide basis. The nodal load forecasts are constructed using participation factors⁴⁹ supplied by the EMC.
- System security conditions for each half-hour are supplied by the PSO.

The variations in standing offer data by dispatchable generators are the offers the generators are making for their plant into the market. We discuss this further in section 9.4.

9.3.1 Gate Closures on Offers

There is a firm gate closure after which the market software cannot accept any changes in offers. There is also an earlier effective gate closure after which any change in offer, although accepted by the software, is subject to market surveillance investigation.

- Firm gate closure: offer variation data for a dispatch period must be submitted no less than 5 minutes prior to the dispatch period.
- Although not formally a gate closure, the last time for changing offers, under normal circumstances, is 65 minutes prior to the beginning of the dispatch period. Any offer variation data submitted within 65 minutes of the beginning of a dispatch period is reported by the EMC to the market surveillance panel for investigation.

9.3.2 Market Outlook Scenarios

Starting 0900hrs of each day D-8, generators offer ahead for a period of 6 days which ends at the end of day D. Schedules and prices for the 6-day period are published each day. For day D, the schedules and prices are first available on day D-6. Several nodal load forecasts (normal, medium and low) are prepared by the EMC based on information provided by the PSO.

These 6-day scenarios enable market participants to gain some understanding of the market conditions that lie ahead. In particular, market prices and security issues are signalled well in advance, providing opportunity for market participants to modify their anticipated behaviour.

9.3.3 Pre-Dispatch Schedules

The pre-dispatch process has a fixed horizon, looking ahead for the current day and the next day, with a maximum look-ahead of 36 hours and a minimum look-ahead of 14 hours. Any offer made for a dispatch period is assumed to be valid, and will be binding unless superseded by a later offer for the same dispatch period.

Several load scenarios are run and published. These scenarios represent various load forecasts from low to high estimates of the load for the day in the same way as for the market outlook scenarios. They are used to give market participants additional information about possible market conditions.

⁴⁹ Participation factors are the proportions of the Singapore total load allocated to each load node.

9.3.4 Short-term Schedules

The short-term schedules are produced every half-hour and cover 12 consecutive periods immediately after the period in which the short-term schedule is published. They were introduced after the commencement of the NEMS with a view to allowing a shorter gate closure period for offers. They provide market participants with more timely and up-to-date indicative prices and dispatch schedules. A single load projection is used for each short-term schedule.

9.3.5 Real-Time Market

For each on-coming half-hour – the actual dispatch period – the offers, system data, reserve and regulation requirements, security conditions and load projection determine the real-time market. At this point, a single load projection is made.

The real-time market is run in advance of the dispatch period and gives ex ante prices so that all participants are able to see the market prices before the event. It is very unlikely that the outcome of the dispatch period will be exactly as predicted or scheduled. However, generators and load face the ex ante market prices irrespective of the outcome, unless there were errors (excluding an inaccurate nodal load forecast⁵⁰) in the information used to determine the real-time market. In such a case, a re-run would be conducted to obtain revised prices.

9.4 THE OFFER PROCESS

9.4.1 Energy, Reserve and Regulation Offers

Generators make offers to supply energy, reserve, and regulation for each of their units in each half-hourly dispatch period in which they want to operate. They are similarly permitted to offer interruptible load through load facilities to supply reserve. Offers can vary for each half-hour, and are assumed to stand, unless modified, from the time they are made through to dispatch. The market does not distinguish between offers used for the market outlook, pre-dispatch and real-time processes. It simply uses the most recent offer made for each half-hour.

Key features of the generator offer process are:

- *Standing offers are required.* Generators are required to make standing offers into the market. The standing offers form a pattern for a week. The use of standing offers is particularly valuable for smaller generators, since it eases the administrative burden of participating in the market⁵¹.
- *Continuous adjustment of offers.* Market participants are allowed to continually adjust their offers up to the gate closure described above⁵².
- *Up to 10 price/energy quantity bands.* Generators may make energy offers consisting of up to 10 price/quantity bands (tranches) for each facility for each half-hour.

⁵⁰ Nodal load forecasts are very unlikely to be perfectly accurate.

⁵¹ For example, generators who wish their capacity to be fully dispatched always, when it is available, can use a standing offer of, say, zero or SRMC, and only change it in exceptional circumstances.

⁵² Although, as noted above, offers modified within the 65 minutes may be subject to scrutiny from the market surveillance and compliance panel.

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- *Up to 5 price/reserve and regulation quantity bands.* Generators and interruptible load may make reserve offers (of different classes) and generators may make regulation offers if they are registered to do so.
- *Combined offers.* Energy, reserve and regulation are all offered simultaneously, and are co-optimised by the market clearing model. The model respects the trade-offs between the commodities so that a facility will not be scheduled to produce more energy, reserve and regulation than it can simultaneously manage. This is discussed further in section 9.5.1.
- *Offers at a node.* Energy offers for each generation facility are made at the node where that facility is located.

9.4.2 Consumer Bidding

There is no consumer (demand-side) bidding for energy in the NEMS at this time. Load for each period is estimated by the EMC based on information provided by the PSO. Consideration may be given to load side bidding if nodal pricing is extended to load.

9.4.3 Interruptible Load

Since 1 January 2004, interested parties have been able to register their load facilities to offer interruptible load in the NEMS.

9.5 ANCILLARY SERVICES

Ancillary services are services required by the PSO to meet contingencies and ensure the secure supply of energy. There is a range of ancillary services required by the PSO, some of which are provided for in the wholesale market and others obtained separately by contract. Reserve and regulation are provided as an integrated part of the market clearing process, while other ancillary services are contracted for separately.

9.5.1 Reserve and Regulation Requirements to Meet Outages and Variations in Load

Reserve is generation capacity that is required in case of an unexpected outage of scheduled plant. Because generating units may fail without warning, some reserve capacity has to be made available to the system to quickly correct any imbalance and maintain reliable supply. Reserve is a significant factor in the Singapore system since some generating units (600MW thermal units, for example) are large relative to the total load. Three levels of reserve are provided for in the system: 8 seconds, 30 seconds and 10 minute.

Regulation, or “load-following”, is required to cover second-to-second variations in load away from estimated load. This is a normal operational requirement.

The quantity of reserve required by the PSO is determined by the expected size of a contingency. It is calculated dynamically from:

- The size of largest unit generating;
- The stability of the unit under contingencies; and
- The correlation of unit failure with other contingencies.

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A generator would wish to receive payment for the reserve and regulation it provides because it forgoes the opportunity of being dispatched fully, by being partially available for PSO to call on it for reserve and regulation, as and when required.

Reserve in Singapore can be provided by generation facilities and load⁵³. For a facility to provide reserve as quickly as in 8 seconds or even in 30 seconds, it needs to be already spinning and synchronised. In most instances, that requires the unit to also be supplying energy, with reserve capability coming from its ability to ramp up its scheduled output very quickly. Since not all plants have this technical capability, a plant has to be certified as meeting the requirements for registration to provide reserve before it can be offered in the reserve market.

There are also different reserve provider groups for each class of reserve. These groups represent the reliability of different reserve sources in providing reserve, and their effectiveness in curtailing falls in system frequency. For example, some generating stations may have a poor record for response. Reserve provider groups are a means of correcting this variability:

- All reserve providers are assigned by the PSO to a reserve provider group for each class of reserve they provide.
- The MCE discounts the quantities scheduled from reserve provider groups to account for the likelihood of a lower quantity of reserve being provided when it is requested.
- The reserve price paid to reserve provider groups is correspondingly discounted.

Since a facility's capacity may be available for both energy and reserve / regulation, the MCE must consider the optimal trade-off between the offers for reserve, regulation and energy. In solving the markets for each class of reserve and regulation, the MCE simultaneously finds the lowest cost solution (in terms of the offers made) that trades off between these products for the various facilities. Within the MCE, optimisation of the supply of energy must account for the minimum running level of facilities that provide reserve. The overall optimal solution may result in a unit being run "out of merit" for energy so that the unit is available for reserve⁵⁴.

Offers for reserve from a generator can only be made in association with a corresponding offer for energy. Part of the standing capability data for the plant is a function relating its reserve capability to its energy capability. This relationship is entered into the MCE.

The cost of reserve is recovered from all generation facilities operating in that half-hour by a levy that varies according to the contribution of each facility to the requirement for reserve. A variant of the "runway" model is used to calculate the allocation to each dispatchable facility. The model weighs the cost more heavily to the facilities generating higher quantities, and on those with a poor reliability history.

⁵³ In some markets, interruptible load plays a significant role in supplying reserve. Since it can be switched off very quickly it is well positioned as a supplier of 8 second and 30 second reserve.

⁵⁴ Since often a facility must be running in order to be available for reserve, it may be dispatched for energy even though its energy offer is higher than that of the marginal plant for energy. This is acceptable because there is no cheaper energy and reserve solution for the system as a whole. The reserve price received by such a plant will compensate it for the shortfall between its energy offer price and the energy spot price.

9. Wholesale Market Operation...

The cost of regulation is recovered from load and the first 10 MW of each generating facility being dispatched, since it is load and small variations in generation that create the need for regulation.

9.5.2 Other Ancillary Services

Other ancillary services such as reliability must-run service, reactive support and voltage control service and black start capability, while important, form a small part of the total value of the market. In many cases, they can be provided by only a few sources. It is not worthwhile creating spot markets for these services. Instead, they are supplied under contracts negotiated with market participants by the EMC acting on behalf of and under direction from the PSO.

The costs of supplying these ancillary services are recovered from market participants as part of the monthly energy uplift charge which despite its name is charged for every dispatch period.

9.6 PUBLISHED RESULTS

For each dispatch period, and each of the market outlook scenarios and pre-dispatch scenarios, the EMC publishes the following data:

- Total load;
- Transmission losses;
- Reserve requirements by reserve class;
- Regulation requirements;
- Energy price for each market network node at which a generation facility is located;
- USEP;
- Reserve prices by reserve class and reserve provider group;
- Regulation prices;
- Any energy shortfall reported by the MCE;
- Any reserve and regulation shortfall reported by the MCE; and
- List of security constraints and generation fixing constraints applied.

9.7 MARKET SUSPENSION AND ADMINISTERED PRICING

Administered prices are prices that have not been calculated by the MCE in the normal way. This could happen for two reasons – either the MCE process has failed in some way, or because the market has been suspended by the EMA. If the MCE has failed in any dispatch period, then the EMC will endeavour to re-run the process to produce prices for that half-hour. If it cannot do this, then prices will be set to be the average of the corresponding prices for the preceding thirty days.

Market suspension is an extreme action. Only the EMA has the power to suspend the market, and only in circumstances where the operation of the market cannot continue. It may not be done, for example, merely because prices in the market are very high. The EMA may suspend market operations in the following circumstances:

9. Wholesale Market Operation...

- The declaration or anticipated declaration of a state of emergency by the Government of Singapore;
- The outbreak of war or similar conflict;
- Significant and continuing degradation of the power system as the result of a natural or man-made disaster;
- The EMA receives notification from the EMC to the effect that circumstances have arisen, other than the inability of the EMC to meet its financial obligations under the market rules, which mean that it is no longer possible or practical for the EMC to comply with its non-financial functions and duties or meet its non-financial obligations under the market rules; or
- The EMC requests that the market be suspended due to an emergency situation that has required or will imminently require the EMC, the PSO or both to evacuate their respective principal control centres and move into their respective back-up control centres.

Where market operations are suspended, facilities will be dispatched and market participants will be settled financially for injections and withdrawals of electricity in the manner and on the basis of prices determined by the EMA in consultation with the EMC and the PSO.

10. WHOLESALE MARKET SETTLEMENT

This section examines the settlement process in the wholesale market. The EMC settles all transactions in the spot market, besides performing several other functions. The settlement process uses information from the dispatch, including the ex ante prices and dispatch schedules, and from the metered outcome of each dispatch period. It uses this information to calculate the payments to be made to and by generators and loads participating in the wholesale market.

The items settled are principally:

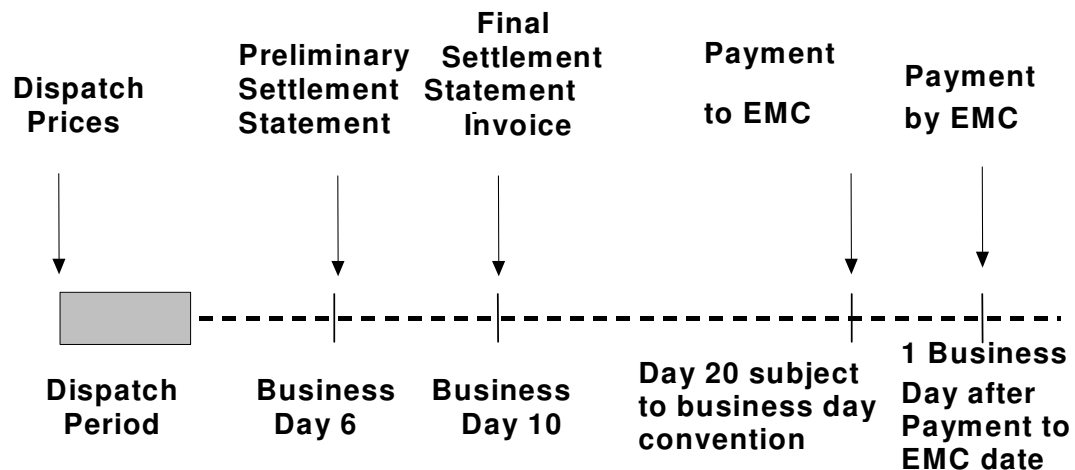
- Energy;
- Reserve;
- Regulation;
- Vesting contracts between the generators and the MSSL;
- Hourly energy uplift charge covering any deficits and surpluses from imbalance in the market receipts and payments;
- Monthly uplift covering EMC's and the PSO's administrative costs, the cost of contracted ancillary services; compensation paid to market participants where compensation is expressly provided in the rules, amounts paid or received following the resolution of disputes and other costs approved by the EMC and EMA;
- Bilateral contracts between market participants, if requested by the parties; and
- Financial transmission rights.

10.1 SETTLEMENT TIMETABLE

The settlement process begins at the time of dispatch, when prices are available, and ends when invoices for each dispatch period are produced. Invoices are generated on business days, on a rolling basis.

Key steps in the settlements timetable re shown in Figure 5.

Figure 5. Settlement Timetable



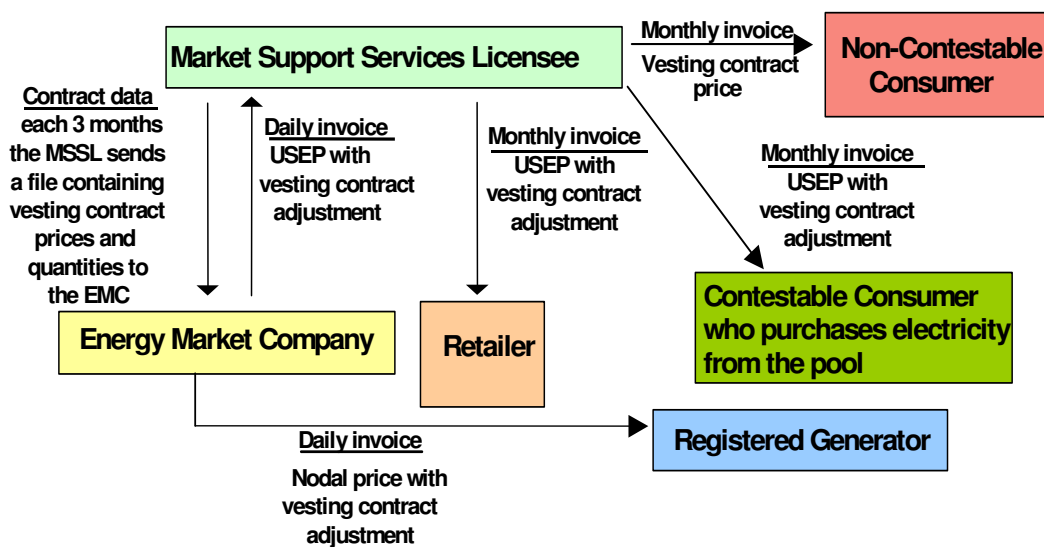
10.2 SETTLEMENT SURPLUS

Nodal prices reflect marginal losses and economic rents from congestion while power flows reflect average losses. This difference gives rise to a “settlement surplus” because marginal losses exceed average losses. The surplus should initially be minimal in the Singapore market, because the transmission system is largely unconstrained and losses are small. It is returned to consumers by being credited to the energy uplift. Import and export flows through the intertie with Malaysia also impact on this “settlement surplus”.

10.3 SETTLEMENT OF VESTING CONTRACTS

Vesting contracts are settled by the EMC in the wholesale market and by the MSSL in the retail market as shown in Figure 6.

Figure 6: Vesting Contract Settlement



10.4 UPLIFT AND OTHER PAYMENTS

Market participants are liable for several uplift payments and market and administration costs:

- Uplift payments arising from payments for reserve, regulation and energy as well as import and export flows through the intertie with Malaysia. These are charged half hourly;
- Monthly energy uplift payments (actually charged half hourly however it is charged at a constant rate in each month though rate changes from month to month) relating to contracted ancillary services, import and export flows, compensation, amounts owing as the result of the resolution of disputes, etc.; and
- The EMC's and the PSO's administrative costs.

11. THE RETAIL MARKET

This section outlines the role of the retail market in the NEMS and how the retail market will operate.

The NEMS has a structure that enables the retail electricity system to develop into a fully competitive market. The institutional arrangements include competitive retailers, smaller contestable consumers (although not all are contestable immediately) and larger contestable consumers who can also participate directly in the wholesale market. A key feature of the Singapore market is the existence, powers and responsibilities of MSSL.

The retail market does not come under the jurisdiction of the market rules and the EMC. It is created and regulated under the Electricity Act and under electricity licences and codes of practice issued by the EMA.

11.1 CONTESTABILITY SCHEDULE

Contestability is structured so that the larger consumers are made contestable first through to the small consumers, including households last:

- Since July 2001, consumers with a maximum power requirement of 2MW and above have been contestable.
- In addition to the existing contestable consumers at market start, the first phase⁵⁵ of consumers who became contestable in June 2003 are those with average monthly usage of 20,000kWh and above. There are about 5,000 consumers in this category.
- The next phase of retail contestability – involving those consumers with average monthly usage of 10,000kWh and above, numbering about 5,000 consumers – commenced in December 2003 and concluded in February 2006.
- Retail competition for rest of the other consumers (about 1 million consumers in total) is being studied.

All of the contestable customers in Phases 1 and 2 had "interval meters" installed in their premises to record consumption in half-hourly blocks (corresponding to the wholesale market dispatch period)⁵⁶.

11.2 ROLE OF THE MARKET SUPPORT SERVICES LICENSEE

The role of SP Services Ltd in the retail sector is to be the supplier of electricity for all non-contestable consumers. SP Services Ltd is required, under its MSS licence, to also provide contestable consumer who does not, cannot or no longer wishes to purchase electricity from a retailer or wholesale market, the service to purchase electricity through SP Services Ltd at prevailing market prices. In addition, SP Services Ltd has the role of facilitating the transfer of consumers between retailers.

⁵⁵ In fact this phase was split in order to ensure a well-managed process of transferring them from MSSL to retailers.

⁵⁶ PowerGrid is linking all of these meters to existing telephone lines to facilitate daily remote meter reading.

11.3 OPERATION OF RETAILERS IN THE MARKET

Retailers may be wholesale market participants who purchase electricity directly from the wholesale market or purchase through the MSSL. Since they are permitted to trade in electricity and are not subject to regulation in the same degree as the MSSL, they may offer contestable consumers contracts different from those available from the MSSL. They can bundle energy and other charges into a single invoice, charge a price other than the USEP for energy and offer additional services to the consumer.

For retailers with affiliated generators, the retail load creates a natural hedge for the affiliate's generating capacity and against spot market volatility. This aspect of the market design is expected to heighten the desire for such vertically integrated companies to expand their retail load.

12. TRANSMISSION AND METERING

This section introduces the transmission system which is owned, operated and maintained by SP PowerAssets in accordance with the Transmission Code and as directed by the PSO under the terms of their operating agreement, as well as in accordance with the provisions of connection agreements with connected entities. This section also describes the metering arrangements in the NEMS. Metering for wholesale and retail market purposes are governed largely by the provisions of the Metering Code.

12.1 GRID CHARGES

SP PowerAssets recovers its costs of providing transmission services via grid charges. In general, the grid charge structure is made up of the contracted capacity charge (fixed component) and the usage charge (variable component), which is further sub-divided into the peak charge and the non-peak charge.

The various classes of customers served by SP PowerAssets are:

- (a) Ultra High Tension - for consumers taking ultra-high tension supplies (230kV and above).
- (b) Extra High Tension - for consumers taking extra-high tension supplies (66kV).
- (c) High Tension-Large - for consumers taking high tension supplies (22kV and 6.6kV) with a Contracted capacity of at least 1700kW.
- (d) High Tension-Small - for consumers taking high tension supplies with a Contracted capacity of less than 1700kW.
- (e) Low Tension-Large - for large industrial and commercial consumers taking low tension supplies (400V/230V). These are contestable consumers with time-of-day metering.
- (f) Low Tension-Small - for all non-contestable consumers taking low tension supplies.

Low Tension customers are only levied on a usage basis, where for Low Tension-Large due to the presence of time-of-day metering, allows for measurement of consumption on a peak and non-peak basis; hence these customers pay both peak and off-peak charges.

12.2 METERING ARRANGEMENTS

The rules relating to metering in Singapore are contained principally in the Metering Code. For the time being, the "metering equipment service provider" (i.e., the entity that provides, installs and maintains the meters) for the wholesale and retail markets is SP PowerAssets, except for meters for generation facilities which are provided and installed by the generators themselves. All other metering-related services (meter reading, meter data management, etc.) are performed by the MSSSL.

All wholesale market participants are required to have revenue-quality metering that meets certain technical specifications including, for example, falling within an allowable measurement accuracy range. Wholesale meters must be interval meters that can

12. Transmission and Metering...

record data half-hourly in order to allow for settlement in the wholesale market (since settlement is based on half-hour settlement intervals).

13. MANAGING FINANCIAL RISK

The NEMS will expose the industry to a certain level of volatility. This section describes how participants can manage their financial risk through the use of financial contracts.

13.1 FINANCIAL CONTRACTS

Electricity markets are very volatile and can experience periods of unexpected (and sometimes extreme) high and low prices. The wholesale market in Singapore is not designed to eliminate or be immune to price volatility – indeed, it is important to the market that prices move freely. As a result, the design also recognises the need to allow participants to manage price risk.

To manage this price risk, market participants, especially retailers and consumers, need to hedge against price changes. They may seek to reduce their exposure to volatile spot prices by entering into short or long term bilateral contracts that set an agreed price for a defined quantity of electricity at specified times. Many different types of financial risk management contracts are possible in the electricity market. The most common is a Contract for Differences (CfD).

Bilateral financial contracts are outside the wholesale market in the sense that they are not taken into account in the physical dispatch process (except indirectly through generator offer behaviour) and are not in any way regulated by the market rules. The facility exists, however, for the parties to the contract to settle the contracts through the EMC's settlement system.

13.1.1 An Example of a Contract for Differences

Figure 7 shows a bilateral CfD hedge between a retailer and a generator. The hedge strike price has been agreed to be \$40/MWh. When the spot price exceeds the strike price, the generator pays the retailer the difference between the spot price and the strike price. When the spot price is less than the strike price, the retailer pays the generator the difference between the spot price and the strike price. The net effect is that both the retailer and the generator effectively see a price of \$40/MWh for the volume of energy covered by this hedge contract (assume 500MW each hour) – thereby limiting the spot price risk for both parties.

If the generator only generates 400MW in a given hour and the retailer consumes 600MW in the hour and the spot market price is \$80/MWh, the financial settlement is:

- Generator earns in the spot market $400 \times \$80 = \$32,000$: spot market settlement.
- Retailer pays in the spot market $600 \times \$80 = \$48,000$: spot market settlement.
- Generator compensates retailer for $500 \times (\$80 - \$40) = \$20,000$: side settlement.
- The net effect is that the generator earns $\$32,000 - \$20,000 = \$12,000$. (This can also be seen as it getting $\$40 \times 500$ (\$20,000) for its contract but having to buy from the market $100 \times \$80$ (\$8,000) to meet its shortfall in generation).
- Similarly the net effect is that the retailer pays $\$48,000 - \$20,000 = \$28,000$. (This can also be seen as it paying $\$40 \times 500$ (\$20,000) for its contract but having to buy from the market a further 100 at \$80 (\$8,000) to meet its shortfall in contract cover).

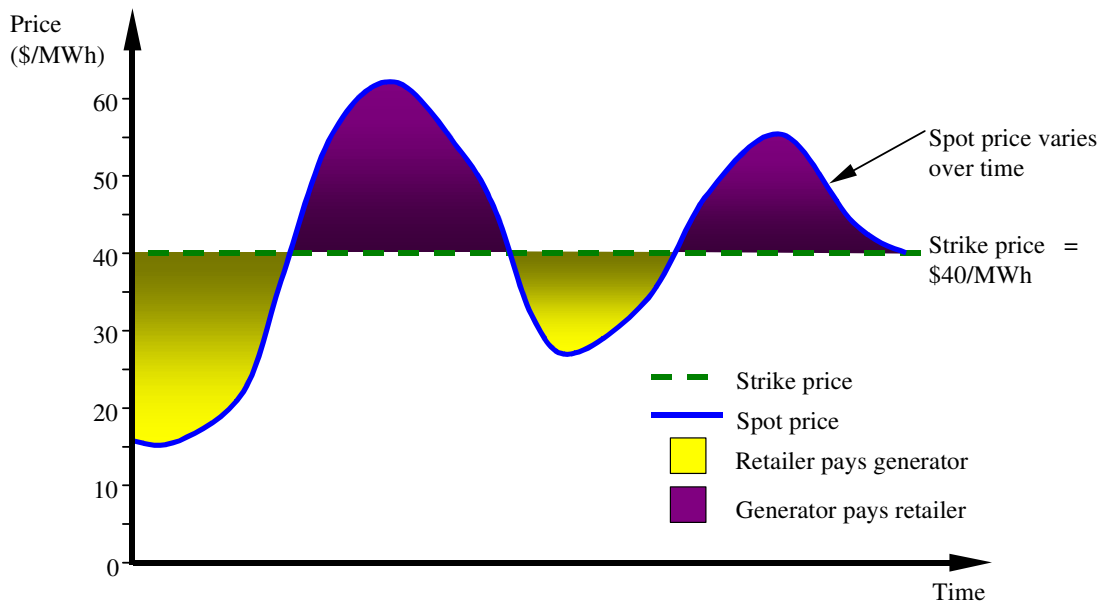
13. Managing Financial Risk...

In this example, the retailer has hedged most of its risk and is only exposed to the spot market for 100MWh. The generator is over-hedged and has to buy at a high spot price to meet its hedge quantity.

A generator can control its exposure to spot market risk by offering its capacity in the market to cover its contracts. It does this by meeting its contract obligation from its own generation as long as its short-run marginal cost is below the market price.

Vesting contracts behave exactly like the CfD described above between the generators and the MSSL.

Figure 7. Example CfD Hedge



14. OUTAGE AND EMERGENCY PLANNING

This section outlines the obligations of the PSO to coordinate outages in the NEMS. It also details the responsibilities of the various participants in ensuring their own emergency preparedness.

14.1 ANNUAL OUTAGE PLAN

The PSO is responsible for the coordination of outages in the NEMS and is required, among other things, to conduct an annual outage planning process. In support of this, each market participant is required to prepare its own long-term outage plans and to submit outage requests at various times for approval, confirmation and final consent by the PSO.

The outage planning process is as follows:

- Each market participant supplies to the PSO a long-term outage plan.
- The PSO reconciles the outage plans supplied by market participants into a provisional annual outage plan.
- If there are conflicts in the plans from different market participants, they are notified by the PSO and are expected to attempt to resolve the conflicts and to make re-submissions accordingly.
- If the conflict cannot be resolved by the market participants, the PSO resolves it according to precedence determined by submission timestamp.
- The PSO publishes the approved annual outage plan.
- Market participants can submit revised outage plans for approval after publication of the approved annual outage plan. Any outages approved or withdrawn in a given year, after publication of the approved annual outage plan, are included in the PSO's outage plan updated as and when required.
- The PSO can cancel a planned outage for which it has previously granted approval if it later determines that the planned outage would pose a risk to the reliable operation of the power system

In addition, as the time for a planned outage draws near, market participants are required to obtain final approval for the outage from the PSO, PSO's confirmation of the outage and, within hours before the commencement of the outage, PSO's final consent to the outage.

14.2 SINGAPORE ELECTRICITY EMERGENCY PLAN AND SINGAPORE POWER SYSTEM RESTORATION PLAN

The PSO is required to prepare and publish the Singapore Electricity Emergency Plan and the Singapore Power System Restoration Plan.

The PSO, the EMC and market participants are obliged to ensure their own emergency preparedness and ability to meet power system restoration obligations, including regular and real-time testing. Market participants and the EMC must produce emergency preparedness plans that are co-ordinated with the Singapore Electricity Emergency Plan as well as restoration plan attachments that are coordinated with the Singapore Power System Restoration Plan.

14. Outage and Emergency Planning...

The purpose of the Singapore Electricity Emergency Plan is to alleviate the effects of an emergency on the power system, with regard to public health and safety.

The Singapore Power System Restoration Plan covers restoration of the power system following a major contingency event or emergency. It details the planning, testing, information, load reduction, load restoration and communication protocols necessary to implement effective restoration of the power system. In addition to describing the roles of the EMC, the PSO and various market participants in system restoration activities, the Singapore Power System Restoration Plan includes:

- Plans for managing major disturbances on the power system that black out all or a portion of the power system; and
- Plans for the testing and verification of emergency preparedness, facilities and procedures.

15. APPENDIX 1 - GLOSSARY

15.1 ACRONYMS

CfD	Contract for Differences
EMA	Energy Market Authority of Singapore
EMC	Energy Market Company, the market company licensee
GWh	Giga-Watt hour (1,000 MWh or 1,000,000 kWh)
kW	kilo-Watt
kWh	kilo-Watt hour
MCE	Market Clearing Engine, the computer software that creates dispatch schedules and determines market clearing prices
MPR	Market Participant Retailer
MSSL	Market Support Services Licensee
MW	Mega-Watt
MWh	Mega-Watt hour (1,000 kWh)
NEMS	National Electricity Market of Singapore
NMPR	Non-Market Participant Retailer
PSO	Power System Operator, the division of the EMA responsible for ensuring the secure operation of the power system
PUB	Public Utilities Board
USEP	Uniform Singapore Energy Price, the energy price used to settle all energy transactions deemed to occur at the "Singapore Hub" (essentially, the price used to settle loads)
VoLL	Value of Lost Load

15.2 DEFINITION OF TECHNICAL TERMS

Ancillary services: Those adjunct services necessary to ensure the security and reliability of the power system such as reserve, regulation, black start, reactive power etc.

Bilateral contract: In the context of the Singapore NEMS, a contract for financial settlement between two parties.

Co-generation: A type of generation plant that draws its energy from a related industrial process or that uses its waste heat for such a process.

Contestability: The right to choose between electricity suppliers.

Dispatch: The process by which generation is co-ordinated in real time to meet demand.

Dispatchable generator: A generator that is capable of following dispatch instructions from the PSO.

Dispatch Period: A thirty-minute time interval beginning on the hour or the half-hour during which dispatch is being effected.

Energy shortfall: The amount by which energy supplied is less than the load to be met.

Ex-ante: Literally means “before the time or event”. A market that has ex-ante pricing determines prices before energy is injected or consumed. The Singapore wholesale market has ex-ante pricing.

Generation: The production of electricity.

Hedge: A financial instrument that protects against volatility in prices.

Intertie: A transmission interconnection between the Singapore transmission system and an electricity system that is outside Singapore and under the control of an operator other than PSO.

Load shedding: The situation when there is a shortage of supply, and demand has to be reduced (or “shed”) to restore the balance between generation and demand.

Marginal generator: The scheduled generator that supplies the last unit of electricity to meet demand.

Market model: The representation of the Singapore electricity system used in the MCE.

Market clearing price: The spot market price.

Market operator: The company, referred to in the Electricity Act as the “Market Company”, which holds an electricity licence authorising it to operate any wholesale electricity market (the EMC).

Metering: The measurement of the flow of electrical energy.

Nodal price: An electricity price at a specific location.

Node: Any of the injection or exit points on the transmission system in the market model.

Non-contestable consumers: Consumers who are required to take supply from the MSSL.

Offer: A set of price / quantity pairs placed in the market for a generating facility.

Real-time dispatch: A schedule determined by the MCE that contains the quantities of energy, reserve and regulation scheduled in respect of a registered facility.

Real-time market: The wholesale electricity markets operated by the EMC for energy, reserve or regulation.

Regulation: In relation to a generating unit, the frequent adjustment to its output so that any power system frequency variations or imbalances between load and the output from generation facilities can be corrected.

Regulator: The entity that has regulatory oversight over the Singapore electricity market (the EMA).

Reserve: An ancillary service consisting of generation capacity that is available to, or load that can be interrupted by, the PSO in the event of an unexpected outage of scheduled plant.

Security constraint: A generic constraint defined by the PSO to be used as input data to the MCE to restrict dispatch solutions for the purpose of maintaining the security of the power system.

Settlement account: An accounting balance that the EMC maintains for each market participant for the purpose of accounting for settlement amounts determined in accordance with the market rules.

Settlement surplus: With regard to the spot market settlement process, the difference between the aggregate amount paid by consumers and the aggregate amount paid to generators.

Spot market: The "real-time" market consisting of a half-hourly auction of electricity by generators to meet projected demand.

Transmission: The conveyance of electricity by means of a system which consists wholly or mainly of electric lines and electrical plants. The system is used for conveying electricity (a) from an electrical plant to a substation; (b) from one electrical plant to another or from one substation to another; or (c) from a substation or electrical plant to the electrical installation serving the consumer's premises or directly to the consumer's premises (where such premises are not served by an electrical installation).

Unit Commitment: The operating state of generating units over time where in each time interval a unit may be operating or not.

Uplift: A charge levied on wholesale market participants to recover costs otherwise not recoverable in the spot market.

Vesting contract: A contract or other financial arrangement between a market support services licensee and a generation licensee in a form approved by, and designated as a vesting contract by, the Authority.

16. APPENDIX 2 - FACTS AND FIGURES

This section presents a range of statistical information relating to the Singapore economy, as well as details of the generation, transmission and retail components of the Singapore electricity industry.

16.1 THE SINGAPORE ECONOMY

The Singapore Government has adopted a free market approach to economic management, with an open economy based on trade and investment. Figure 8 shows key demographic and economic statistics for the last five years.

Figure 8. Singapore Demographic and Economic Statistics

Statistic	2003	2004	2005	2006	2007
Population (million)	4.12	4.17	4.27	4.40	4.59
Labour Force (million)	2.31	2.34	2.37	2.59	2.75
Unemployment Rate (% , average)	3.6	3.6	3.3	2.7	2.3
GDP (\$billion)	162.3	184.5	199.4	217.0	243.2
Annual Growth in Productivity (%)	4.8	7.2	2.8	1.5	-0.9
CPI (% change)	0.5	1.7	0.5	1.0	2.1
Balance of payments (\$billion)	11.77	20.47	20.40	27.00	29.30
Exchange rate (S\$ per US\$, average)	1.74	1.69	1.66	1.59	1.51

Source: *Yearbook of Statistics Singapore 2008 (Dept. of Statistics)*

16.2 THE SINGAPORE ELECTRICITY INDUSTRY

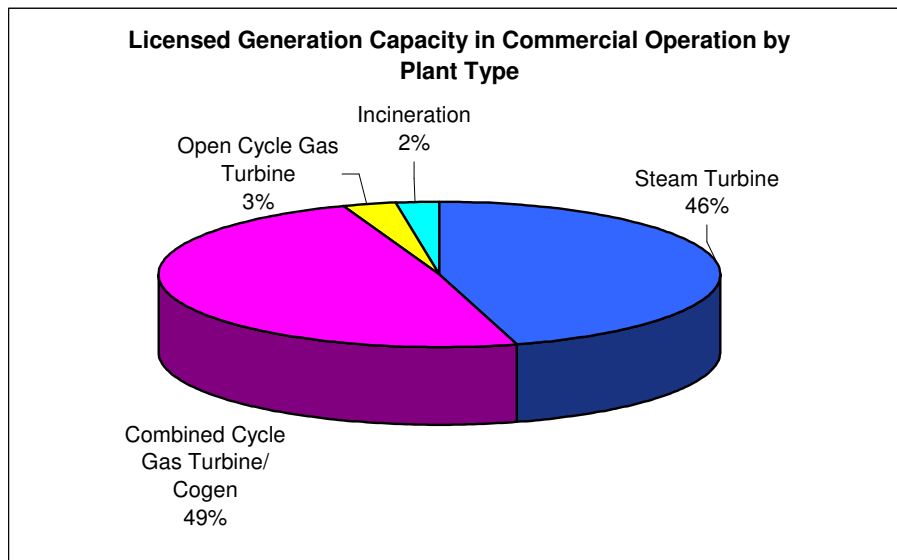
16.2.1 The Generation Sector

The generation sector produces electricity by burning fossil fuels – primarily natural gas and oil. The share of generation capacity by plant type is shown in

16. Appendix 2 - Facts and Figures...

Figure 9. Some 96% of electricity generation capacity in the year 2008 was either oil, or combined oil and natural gas thermal generation plant. .

Figure 9. Licensed generation capacity in commercial operation by plant type,



Singapore has seen rapid growth in its electricity generation volume and capacity, as well as in peak demand in line with Singapore's high rate of economic growth.

- Peak demand has been growing at 3.5% per annum compounded over 10 years between 1999 and 2008.
- Total electricity generation volume grew at a compound rate of 4.0% per annum between 1999 and 2008 – increasing by a total of 48% over 10 years.

As of end 2008, 8 companies have been issued generation licenses. The licensed generation capacity, as shown in Figure 10, represents the maximum allowable generation capacity that can be installed by the respective generation companies. This licensed capacity includes current capacity in commercial operation and capacity yet to be commissioned.

Figure 10. Generation Company

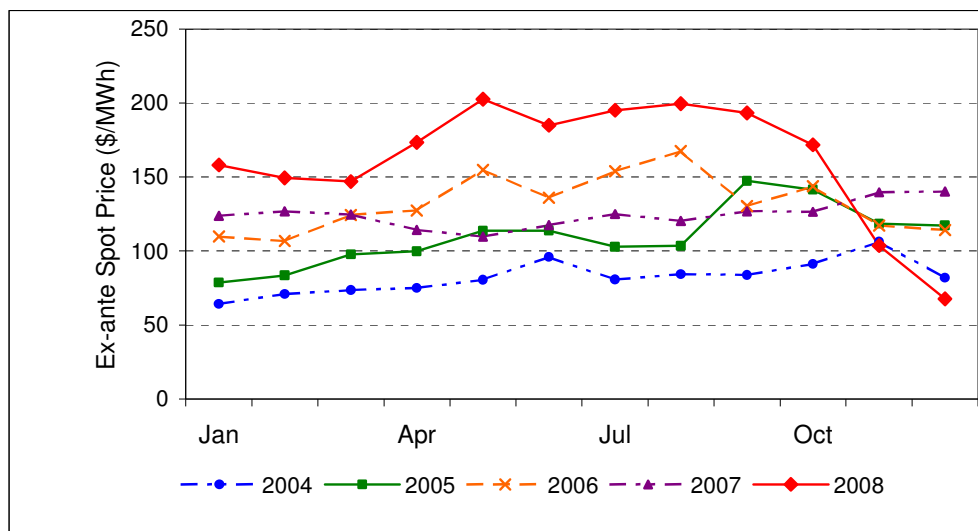
Licensed Capacity

Company	Authorised Generation Capacity (MW)
Senoko Power	3,300
PowerSeraya	3,100
Tuas Power	2,670
SembCorp Cogen	785
Island Power Company	800
Keppel Merlimau Cogen	1,400
National Environment Agency	251

Keppel Seghers	24
Total	12,330

A history of spot prices in the Singapore Electricity Pool is shown in Figure 11. Due to the high proportion of generation produced from oil and natural gas, pool prices have substantially reflected changes in the price of oil and natural gas⁵⁷.

Figure 11. Wholesale Market Spot Price History



16.2.2 The Network System

The system operates on a frequency of 50 Hz, and consists of the following infrastructure:

- The high voltage transmission system comprising a network of 400kV, 230kV and 66kV substations interconnected by underground cables. There are 99 substations: 3 of 400kV, 15 of 230kV and 81 of 66kV, served by 5,817 km of underground cables.
- The low voltage transmission (or distribution) system comprising a network of 22kV and 6.6kV substations interconnected by underground cables. There are 322 22/6.6kV substations, 4318 22kV and 5094 6.6kV substations, served by 15,219 km of underground cables.

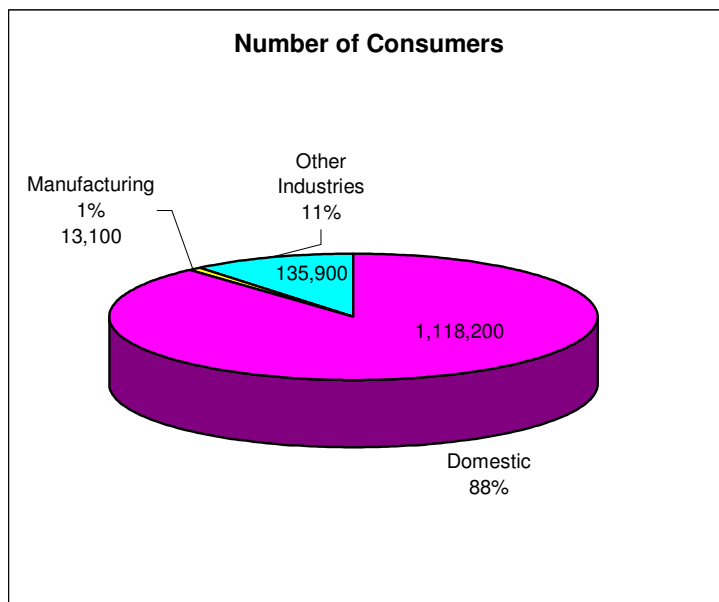
Network losses for 2008 were reported to be 2.77%.

16.2.3 The Retail Market

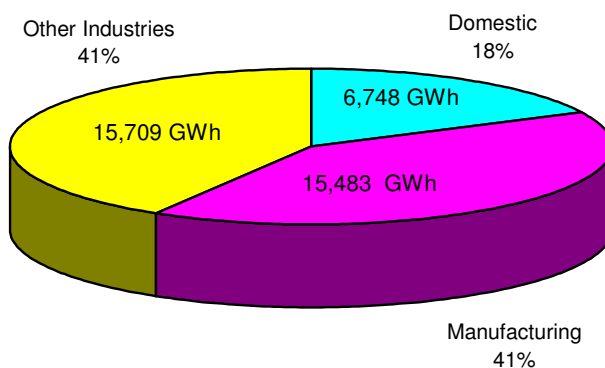
Figure 12 shows the number and type of electricity consumers in Singapore. Residential consumers account for 88% of all consumers but only 18% of consumption, while manufacturing consumers account for 41% of consumption yet constitute only 1% of consumers.

⁵⁷ The price of gas is closely related to the price of oil through contractual arrangements.

Figure 12. Types of electricity consumer and consumption (2008)



Electricity Consumption (GWh)



Consumption growth rates for the three sectors are shown in Figure 13 while sales by sector are shown in Figure 14. With Singapore's tropical climate, there is relatively little seasonal variation in electricity consumption, although there is substantial variation from week-day to Saturday and Sunday. The load profile over a day is very static with few unexpected weather changes to alter demand. This makes estimation of half-hourly load levels very reliable⁵⁸.

⁵⁸ Reliable load estimation is important for the NEMS.

Figure 13. Electricity Consumption Growth Rates 2008 over 2007

Sector	Annual Growth Rate
Residential	-1.1%
Manufacturing	-0.9%
Other Industries	4.9%
Overall	1.4%

Figure 14. Electricity Sales by Sector

Volumes are in GWh

Year	Domestic	Manufacturing	Other Industries	Total	% Growth (year on year)
1999	5,344.1	11,653.5	10,125.4	27,123.3	4.0
2000	5,726.3	12,485.4	10,921.3	29,133.1	7.4
2001	5,984.6	12,239.1	11,372.9	29,596.5	1.6
2002	6,347.6	12,732.9	12,008.7	31,089.3	5.0
2003	6,507.1	13,706.7	11,771.9	31,985.7	2.9
2004	6,524.8	14,446.2	12,200.2	33,171.2	3.7
2005	6,750.3	15,005.0	13,005.8	34,761.3	4.8
2006	6,764.3	15,041.5	14,116.0	35,921.8	3.3
2007	6,820.8	15,621.6	14,977.9	37,420.3	4.2
2008	6,748.5	15,482.6	15,709.2	37,940.3	1.4

A history of average electricity price is shown in Figure 15.

Figure 15. Average Electricity Price

