THE EXTENDED STRAIT

Singapore's Oil Hub

by
Martin Garois
Magnus Nitsch
This work investigates ways by which energy sources shape the space of the global city of Singapore. High electricity demand, the strategic location as a petroleum hub and a highly specialized ship building industry serving the demands of modern oil explorations are major topics that will be discussed. The oil industry, which is prominently located on Singapore’s Jurong Island represents a major case study showing the importance of this industry. More importantly, petroleum products are used by many other industries in the chemical sector as a raw material creating a network, which is visible within the urban fabric.
Dependent Island

As Singapore does not have renewable energy sources, it relies intensively on imports. To improve this situation, renewable sources like solar power, wind energy and others could be a solution. However, the spatial limitations of the island restrict the extent to which these partial solutions could contribute to Singapore's consumption.
Gas-Powered Island

Singapore's energy demand has risen dramatically since its independence in 1965. Energy played a key role for the nation's ambition to join the ranks of developed countries. All of Singapore's electricity was generated through the burning of fuel until recently. Singapore changed its supply system and added gas as a source of electricity due to increasing prices and environmental issues. This gas is imported from Indonesia and Malaysia. Until today, Singapore sources of electricity are hardly diversified; a situation similar to that of Switzerland. The Swiss rely mostly on hydropower and nuclear power for its electricity.

As prices of natural gas are relatively high compared to coal, Singapore is investigating the possibility of building a coal-fired plant for the production of electricity.

The renewable proportion of Singaporean produced electricity is generated through several incineration plants where household and commercial waste is turned into energy.

Electricity Generation Singapore
Singapore has one of the least diversified energy sources worldwide.

*Auto Producers are defined as companies whose main business is not electricity generation and the electricity produced is mainly for the company's own use.*
Solid Waste Management in Singapore

The byproduct of the incineration plants is used to fill-up Sembawang landfill. Waste (byproduct of the incineration plants) is unloaded from the ships at the landfill's transfer building. Lorries then transport the waste to landfill cells where it is discharged and compacted.

Sembawang Landfill

- Commissioned operation: 2009
- Inception year: 1960
- Non-incineration waste: 3,010 cubic
- Capacity: 470,000,000 m³
- Cost: 410,000,000 S$.
- Expected lifespan: 25-45 years.

Transmission Planning Zones

- Zone A: North-West Block
- Zone B: North-East Block
- Zone C: South-West Block
- Zone D: South-East Block
- Zone E: Central Block

Power Plants:
- Karpal Marimeaux Cogen
- PowerSeroys
- SembCorp Power
- Tuas Power Generation
- Tuas South Incineration Plant
- Tuas Incineration Plant
- Sembawang Incineration
- Sembawang Energy

Electricity Retailers

Franchised (SME) Consumers (market to be fully opened ultimately)
Non-Franchised (Large Highland & Commercial) Consumers

Milestones in the Singapore Electricity Market

- 1995 October: Singapore Electricity Pool commenced operations.
- 1998 April: Singapore Electricity Pool commenced operations.
- 1998 September: Government decision on further deregulation.
- 2002 July: 780 MW Consumers become contractable.
- 2004 January: New transmission and distribution load scheme introduced in the electrical market.
- 2004 December: Commission of Phase 2 Tariff Market.
## Energy Reserves

The ASEAN countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Brunei, Burma, Cambodia, Laos, and Vietnam) possess a fair amount of oil and gas reserves, especially in Brunei, Malaysia and Indonesia. The coal industry is most active in Vietnam, Thailand and Indonesia. Renewable energy sources are already present or could be developed in Brunei, Laos and Cambodia due to geographic circumstances and large rivers. Other renewable sources are present, though most of them are underdeveloped due to the lack of funding and political backing.

Singapore does not own any natural resources except biomass obtained through municipal waste. Nevertheless, many Singaporean companies are involved in energy related enterprises all over Asia where they secure the country’s needs in these matters.

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### Proved Energy Reserves, 2008

<table>
<thead>
<tr>
<th>Country</th>
<th>Coal (Million Tonnes)</th>
<th>Crude Oil (Million Barrels)</th>
<th>Natural Gas (Torrillion Cubic Meter)</th>
<th>Hydropower (TWh/yr)</th>
<th>Geothermal Energy (TWh/yr)</th>
<th>Electricity Generation (TWh/yr)</th>
<th>Wind Energy (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vietnam</strong></td>
<td>Coal 150 Million Tonnes</td>
<td>Crude Oil 0.026 Million Barrels</td>
<td>Natural Gas 0.177 Torrillion Cubic Meter</td>
<td>Hydropower 0.005 TWh/yr</td>
<td>Geothermal Energy 0.4 Wth</td>
<td>Electricity generation 0.1 TWh/yr</td>
<td>Wind energy 0.2 GW</td>
</tr>
<tr>
<td><strong>Indonesia</strong></td>
<td>Coal 135 Million Tonnes</td>
<td>Crude Oil 0.099 Million Barrels</td>
<td>Natural Gas 0.177 Torrillion Cubic Meter</td>
<td>Hydropower 0.010 TWh/yr</td>
<td>Geothermal Energy 3.0 Wth</td>
<td>Electricity generation 1.9 TWh/yr</td>
<td>Wind energy 0.2 GW</td>
</tr>
<tr>
<td><strong>Malaysia</strong></td>
<td>Coal 20 Million Tonnes</td>
<td>Crude Oil 0.011 Million Barrels</td>
<td>Natural Gas 0.010 Torrillion Cubic Meter</td>
<td>Hydropower 0.001 TWh/yr</td>
<td>Geothermal Energy 0.0 Wth</td>
<td>Electricity generation 0.0 TWh/yr</td>
<td>Wind energy 0.0 GW</td>
</tr>
<tr>
<td><strong>Philippines</strong></td>
<td>Coal 3 Million Tonnes</td>
<td>Crude Oil 0.005 Million Barrels</td>
<td>Natural Gas 0.039 Torrillion Cubic Meter</td>
<td>Hydropower 0.000 TWh/yr</td>
<td>Geothermal Energy 0.0 Wth</td>
<td>Electricity generation 0.0 TWh/yr</td>
<td>Wind energy 0.0 GW</td>
</tr>
<tr>
<td><strong>Brunei</strong></td>
<td>Coal 40 Million Tonnes</td>
<td>Crude Oil 0.006 Million Barrels</td>
<td>Natural Gas 0.003 Torrillion Cubic Meter</td>
<td>Hydropower 0.000 TWh/yr</td>
<td>Geothermal Energy 0.0 Wth</td>
<td>Electricity generation 0.0 TWh/yr</td>
<td>Wind energy 0.0 GW</td>
</tr>
</tbody>
</table>

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1. **offshore oil field, Brunei**
2. **Gas field, Natuna, Indonesia**
3. **Coal mining, East Kalimantan, Indonesia**
4. **Bukit Batu (North) Central Java, Indonesia**
5. **Pulau Ubin wind farm, Singapore**
6. **Geothermal infrastructure, West Java, Indonesia**
Singapore's Gas Demand

Gas used mainly for the generation on electricity plays a key role in many ASEAN countries, especially in Singapore and Brunei, where this is the primary source of electric energy. In addition, gas is sufficiently available in most countries in Southeast Asia. However, there will be challenges in the future as the demand grows.

“Increasing energy demand in the region is mainly driven by a rapid level of urbanization and industrialization. The region has one of the fastest urbanization trends in the world. It is predicted that, by the year 2025, more than 50 percent of the region’s population will reside in urban areas, as compared with 39 percent in 2000.” (Energy and environment in the ASEAN: Challenges and opportunities, Shankar, Mann, Salihah).

Singapore will face challenges in the future to diversify its electricity generation further as the reliance on gas is not sustainable. Furthermore, as Singapore’s gas resources all arrive via pipelines coming from Indonesia and Malaysia, there is a need to reduce the dependence on these countries by diversifying sources of energy imports.

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**Production and Consumption by Region, 2011 (Mtoe)**

**Distribution of Proved Reserves, 2011 (in percent)**

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**Reserves to Production Ratio, 2011 (years)**
Singapore’s Oil Demand

The situation regarding oil demand in Singapore is different than with gas. Singapore harbor is an important gas station for ships.

“Although Singapore does not produce any oil, it is one of the top bunkering (ship refuelling) ports in the world. In 2010, about 43 million tonnes of bunkers were lifted in Singapore. This is enough to fill over 17,000 Olympic-sized pools.” (MPA Singapore)

In addition, the four refineries located in Singapore produce important raw materials, distributed all over the world. The incoming raw oil is therefore transformed into products with a much higher value. As there is no pipeline, all the oil arrives into Singapore by ships and leaves the same way.

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**Consumption of Oil Products in Singapore, 2011**

**Production and Consumption by Region, 2011 (mtoe)**

**Reserves to Production Ratio, 2011 (years)**

**Distribution of Proven Reserves, 2011 (in percent)**

Despite very little oil reserves of their own, the emerging economies in Asia Pacific consume large amounts of oil. There is a need to import oil from the Middle East to Asia. This fact puts Singapore into a strategic position as a distributor of oil and oil-related products.

![Map of Asia Pacific showing Singapore's oil demand](image-url)
Minerals and Chemicals as Pillars of the Economy

Besides machinery and electrical products, minerals are a major imported product in Singapore. This is due to the high demand by ships, as the Singapore harbor is a bunkering center, the strong presence of refineries and allied industries and the demand for chemical products, which are generated from crude oil within Asia. Singapore has been a location for oil storage since the beginning of the 20th century. In the 1960s, refineries opened up in Singapore due to its strategic location, the proximity to major markets and the political stability. In recent years, the chemical companies in Singapore have increased in number and size and are expected to increase even further resulting in a growing demand for minerals. This development is, nevertheless, threatened by high electricity prices.

<table>
<thead>
<tr>
<th>17%</th>
<th>Electronic integrated circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.6%</td>
<td>Parts and accessories for office machines</td>
</tr>
<tr>
<td>17%</td>
<td>Petroleum oils, refined</td>
</tr>
<tr>
<td>7.3%</td>
<td>Petroleum oils, crude</td>
</tr>
</tbody>
</table>

Net Import Singapore, 2009
Import of mineral products mainly for the transformation into other, more refined, products for the chemical industry.

<table>
<thead>
<tr>
<th>20%</th>
<th>Electronic integrated circuits</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2%</td>
<td>Automatic data processing machines</td>
</tr>
<tr>
<td>19%</td>
<td>Petroleum oils, refined</td>
</tr>
</tbody>
</table>

Net Export Singapore, 2009
Singapore is increasingly becoming a centered on the chemical industry in Asia. With high demand in the emerging regions like China, but also from South Korea and Japan, this sector is expected to grow even further. It is attracting foreign investment because of political stability, the strategic location of its harbor between the Middle East and Asia and lastly by its superior infrastructures. In addition, companies enjoy tax incentives as well as receiving support by the economic development board.
Liquid Hub

The Liquid Hub of Singapore incorporates the harbor and its facilities, Jurong Island especially, and the surrounding region of Johor Municipality in Indonesia and the Islands of Bintan, Batam and Karimun in Indonesia.

As Singapore is one of the three major oil trading hubs in the world, many companies are keen to have a certain volume of oil stored in the region to be able to react fast to market changes. Therefore, oil storage plays a vital role.

Space limitations in Singapore are forcing more and more storage companies to move away from the island state and to set up in the surrounding area, creating a truly tri-national hub.
Competition or Complementation

There are only few oil facilities in the Strait of Malacca. The globally important terminals are in Malaysia. The Port of Singapore is still the most important location for bunkering as well as for the petrochemical industries. It is a very discussed issue if the fast growing oil and petrochemical sector in the region is going to result in stronger competition or if there will be a complementation to the point where a supranational hub is congregated.

1. Port Klang
Port Klang is divided mainly in two ports, each one with its own operator. These are called the North Port and the West Port. Both have oil tank facilities of considerable dimensions. Port Klang is the biggest oil storage harbour in the Strait of Malacca.

2. Port Dickson
Port Dickson is one of the locations of Royal Dutch Shell in Southeast Asia and ExxonMobil, each of them running a refinery at this location.

3. Malacca Oil Storage Terminal
Very near Malacca in Sungai Udang petronas erected a refinery taking a large part of the terrain. Through one major jetty the tankers that brings the crude oil and takes the refining products can dock perfectly even if the depth are quite small.

4. Jurong Island in Singapore
Jurong Island of Singapore is the biggest oil and petrochemical hub in the region and is the preferred location for bunkering of both tankers and cargo vessels because a lot of their main operative actions take place in Singapore.
History of the Oil Hub

The growth of the port’s petroleum trade has been spectacular. In the mid-1930s, a traveller returning after a 25 year leave exclaimed, "the numerous islands with which the entrance to Singapore is studded... an indication of the new Singapore. Large patches of hard yellow soil disturbed by huge oil tanks replaced the green spaces of yesteryear.

Oil did not enter Singapore physically except for the island's own use. Since the product was not owned by Singaporean residents, there was no petroleum market in Singapore.

The oil companies used it as a place where petroleum produced in Netherland India and British Borneo could be collected, blended and distributed. In contrast to Singapore's importance as a merchant and financier in other commerce for petroleum, its principal trade function were handling, storage and shipment. These activities generated a relatively low number of employment opportunities. Petroleum had its greatest effect on economic development through volume and the large demand for ship repair facilities.

The petroleum trade consisted of three main products, namely kerosene, liquid fuel (oil) and motor spirit (gasoline). At the beginning of the century the main constituent of the petroleum trade was kerosene, used primarily as an illuminant by the poorer sections of the population.

But the phenomenal expansion in petroleum exports during the inter-war period resulted almost entirely from the new products of liquid fuel and motor spirit. Liquid fuel was required chiefly for the bunkering of oil-fired ships and to a lesser extent to run industrial machinery, while motor spirit was needed for automobiles.

The story of Singapore's petroleum trade was - and remained - the use which multinational oil companies found for the port in their worldwide operations. Apart from some kerosene imported from the west coast of the United States, petroleum distribution via Singapore was in the hands of two subsidiaries serving three oil majors by 1939: The Asiatic Petroleum Company, established by Royal Dutch Shell, and the Standard Vacuum Company associated with Standard Oil of New Jersey and Standard Oil of New York.

Oil companies were drawn to Singapore because of its geographical advantages - both local and international - and freedom from regulations. Offshore islands afforded a deep-water anchorage adjacent to Singapore harbor, while at the same time allowing safe storage of large quantities of petroleum.

The export of petroleum did not give rise to a merchant class in Singapore, nor did it make it an international petroleum market. The Straits Settlements Commission observed that "Singapore is not a market for the oil, there are no middlemen’s or dealer’s profits involved and oil is merely distributed here from the sake of convenience."

During the inter war period, unlike the period after 1959, there was no question of government intervention through tax concessions, infrastructure provisions or joint ventures to try to increase the role of oil companies in Singapore or linkages arising from the petroleum trade.

The important linkage of dry dock facilities, which oil tankers created in Singapore, is normally associated with a terminal port, where the longer stay of vessels affords the most economically viable place to obtain repairs.

In largely supporting the dry docks, tanker repair contributed to Singapore's economic development in two important respects. One was to add substantially to Singapore's attractiveness as a port. Second, the dry docks helped Singapore to develop a major engineering industry. The docks were judged "one of the most modern ship-repairing establishments in the East" by an "expert and highly critical" witness: "I do not think there is a place in the world in which you can get to work as solid or as sound or as good a job as you can get in Singapore."
Oil: An Imported Industry

Singapore does not have any oil reserves; therefore, the island state relies completely on imports. Due to the geographic location of the world’s oil reserves, most of the imports have their origin in the Middle East. The oil ships have to pass the Strait of Hormuz on their way to Singapore; the biggest chokepoint for oil trade – and the Strait of Malacca, the second largest. As oil demand in countries of Asia is increasing, the importance of Singapore as the "gate" to this chokepoint increases.
Worldwide Oil Imports to Asia

The largest oil exporters are the Middle East, the former Soviet Union and West Africa.

Singapore receives a total of 152.7 billion tonnes of oil per year, which makes it the fourth largest importer of oil in Asia. Singapore’s imports are largely diversified, making it more independent than in the gas sector. The island state receives the largest portion of its oil imports from the Middle East, followed by India, Europe and South and Central America.

Singapore’s Oil Imports, 2011
(Billion tonnes)
Oil tanker

Singapore receives all of its mineral products by ship. The harbor and its accessibility therefore plays a crucial role.
Gas: A Regional Network

In comparison to Singapore’s oil import, the import situation of natural gas is different. Instead of a global oil chain, the gas import structure is based on a regional network. Neighboring countries like Malaysia or Indonesia are providing the gas security for Singapore so far. Due to growing demand in the home countries, Singapore could face a serious shortage of supplies in the near future. Therefore new gas import options like LNG are currently under construction, securing Singapore’s independence in future times.

The new Singaporean LNG terminal is located on Jurong Island and will be operational by the beginning of 2013, opening a new field of markets for growing energy demand. This could benefit companies, which rely heavily on electricity, especially in the chemical industry.

In addition, trading opportunities could develop through the storage of LNG within Singapore, reinforcing Singapore’s position as a global hub for liquid energy.

Dependence on Gas for Energy Consumption in Southeast Asia

Brunei and Singapore are both largely dependent countries on natural gas for electricity generation.

Other than Singapore, Brunei has major gas reserves and is energetically self-sufficient. The same is true with other ASEAN countries.

The independence of Singapore is a certain risk for economic development, due to the tendency towards electricity prices, because of these circumstances.

The opening of Singapore towards a larger LNG market is a first step, though alternatives like coal or renewables sources should be kept in mind.
ASEAN Pipeline Network

As Singapore relies entirely on piped natural gas, it wants to diversify its sources of gas by building a new LNG terminal, which will be operational by 2013.

Even though Indonesia and Malaysia were the second and third largest LNG exporters last year, these countries are now looking to import LNG as a result of their decreasing productivity and increasing demands.

Trade Movements by Pipeline

China is the largest recipient of piped natural gas in Asia. Singapore follows at second place, receiving 6.7 billion cubic meters from Indonesia and 2.3 billion cubic meters from Malaysia.

The problem concerning pipeline trade is the high dependence on other countries, not providing any alternative in case of conflict.

The advantage of pipelines on the other hand is the constant flow of gas, which enables a precise production, so that storage can be reduced to a minimum.

The alternative to piped natural gas is LNG, which requires costly liquefaction and regasification as well as large storage facilities as the incoming flow of gas is constantly changing.

The drive for Singapore in reducing its dependence is understandable, but it has to prove to be economical feasible.
Global Primary Energy Demand

Global demand for energy has risen inexorably in the last 150 years along with industrial development and population growth. Hunger for energy is predicted to continue to rise by at least 50% by 2050, as developing countries like China and India seek to fuel their rapid economic growth. The lion's share of global energy (about 64% at present) is supplied by coal, oil and gas - the fossil fuels." (BBC News)

Since 2000 the country's CO₂ emissions have fallen by 73%.

For 2009, the CO₂ emissions have risen by 18%.

- China: 7,711 million tonnes
- Europe: 3,050 million tonnes
- USA: 5,425 million tonnes
- India: 1,602 million tonnes
- Middle East: 207 million tonnes
- Africa: 122 million tonnes
- South America: 109 million tonnes
- Russia: 184 million tonnes
- Indonesia: 63 million tonnes
- Japan: 55 million tonnes
- Bangladesh: 32 million tonnes
- Pakistan: 29 million tonnes
- South Korea: 30 million tonnes
- Turkey: 29 million tonnes
- Ukraine: 25 million tonnes
- Norway: 24 million tonnes
- China: 39,398 million tonnes
- India: 1,602 million tonnes
- Russia: 184 million tonnes
- Middle East: 207 million tonnes
- Asia & Oceania: 13,246 million tonnes
- South America: 109 million tonnes
- Africa: 122 million tonnes
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Total primary Energy Supply, Singapore, 2009-2010:

- Oil: 7,711 million tonnes
- Gas: 1,602 million tonnes
- Coal: 5,425 million tonnes
- Renewables: 122 million tonnes

Primary Energy Consumption, 2011 (million tonnes oil equivalent)

- Emerging economies in Asia Pacific consume large amounts of oil. However, oil reserves in this part of the globe are relatively small. Oil imports from the Middle East is therefore necessary to meet the demand of local Asian Pacific markets. Singapore occupies a strategic position in this network as it operates as a distributor of oil and oil-related services.

World Market Energy Use, 2010

- Liquid: 35%
- Coal: 25%
- Natural Gas: 32%
- Renewables: 10%
- Nuclear: 2%

Singapore Energy Use, 2011

- Liquid: 98.5%
- Natural Gas: 1.9%
- Renewables: 0.1%
Natuna Gas Field

"Natuna gas field is in the Greater Sarawak Basin about 1100km (700 miles) north of Jakarta and 225km (140 miles) northeast of the Natuna Islands, Indonesia’s northernmost territory in the South China sea.

Discovered in 1970 by Italy’s Agip, the field is the biggest in Southeast Asia with an estimated 46 trillion cubic feet (tcf) of recoverable reserves, but has been developed only recently. The 640km Natuna transportation system is one of the world’s longest subsea gas pipelines, delivering to Singapore."
Liquified Natural Gas (LNG) Trade

"The cost of transporting natural gas per unit of energy to distant markets is much higher compared to oil because of its volume-pressure behavior, and currently usually occurs by pipeline on land, or, increasingly, via liquefied natural gas (LNG) for overseas." (Review of Ways to Transport Natural Gas Energy from Countries which do not need the Gas for Domestic Use; Thomas, Dave; Energy: Elsevier; 2003)

"The biggest obstacle for the LNG trade, which allows the transport of gas over long distances is that, many importing countries do not have the capital to build the huge storage and regeneration facilities." (Review of Ways to Transport Natural Gas Energy from Countries which do not need the Gas for Domestic Use; Thomas, Dave; Energy: Elsevier; 2003)
Singapore's Future: LNG

"Singapore's new liquefied natural gas (LNG) terminal will be able to handle sufficient imports of the fuel to cover all of the country’s power needs, even if piped gas supply contracts with Malaysia and Indonesia are not renewed. Supply will come under pressure because of growing domestic gas demand in Malaysia and Indonesia. What we will do is ensure sufficient capacity to import LNG to meet all of our gas demand," said Chee Hong Tat, the chief executive of Singapore’s Energy Market Authority. Singapore officials have previously said the new terminal was designed to supplement piped gas.
Gas Facilities
1. LNG Terminal, Singapore (2013)

Gas Anchorage Zones
- Tanking Pipes: Explosives
- LPG, PO/LPG, CNG: Chemical Gas Carriers
- Siding: Explosive
- Eastern: Special Purpose
- Eastern: Special Purpose
- "Gas to the City": Pilot Boarding Point
- Off-Boating Points, Jetties

Natural Gas Pipeline from
Northern Gas Field, Indonesia

Natural Gas Pipeline from
Malaysia

LNG Carrier
Advantage for Singapore:
Global market, possibly lower prices due to
competition

Disadvantage:
Reliance on Indonesia and Malaysia

Disadvantage:
High investment costs, unsteady flow
1. ATB Tanjong Rim
2. Pulau Sembu
3. Karimun
4. Jurong Island area
5. Fuel Oil KAPO LNG Terminal, Pengaman
6. Park Outterg
7. Tanjung Linggur
Oil Facilities
1. Tanjung Bulat Terminal
2. Tanjung Pali Terminal (Patal)
3. Literature/Petrochemical Complex
4. Titan Terminal
5. Pasir Gudang Terminals (Vespol & Kiat)
6. Tanjung Lanang Terminals
7. KAOI Terminal (Pioneer)
8. Joring (ExxonMobil) Refinery
9. Pengerang Vessel Terminal
10. Pengerang Fertilizer Terminal
11. Joring Island
12. Pulau Diak
13. Pulau Serian
14. Pulau Karmun Oilfanning Terminal (Pioneer)
15. Pulau Karmun Petroleum Terminal
16. Pulau Andi Berdi (Grispec Terminal (Future))
17. Jaringah Pelabuhan IPOO Terminal
18. Berjaya Tanjung Urban Terminal

Oil Anchorage Zones
19. Tanjung Pelabuhan Petroleum Anchorage
20. Eastern Petroleum Anchorage
21. Very Large Crude Carrier
22. Buoying Refueling
23. Western Petroleum
24. Eastern Petroleum
25. Eastern Buoying
26. (RTH) Petroleum
27. Karmun Offloading Zone (to improve connectivity MSIC Terminal to Singapore)

Gas Anchorage Zones
28. LNG/LPG Gas Carriers
29. Buoying Exploration
30. Eastern Special Purpose
31. Eastern Special Purpose

Gas Facilities
32. LNG Terminal Singapore

* Gates to the City: Ideal Boarding Point
* Offloading Points, Jetty
If Singapore is the petrochemical center of the region, then Jurong Island could be called the petrochemical heart of Singapore. Often referred to as Houston of the East, Singapore’s Jurong Island is already often taken as a model of how to organize a petrochemical sector densely and efficiently. The whole petrochemical industry in Singapore can be considered as a maritime enclave with an intended separation from the mainland. These two islands artificially created to hold this specific sector are highly organized and have special regulations. If the mainland was not so dependent on them it could be said that Jurong Island and Pulau Bukom are not really part of Singapore.
Center of Petrochemical Industries

Jurong Island is right in front of the Pasir Panjang Container Terminal. As visible on the satellite image, Jurong Island and Pulau Bukom gather all the facilities which are meant for primary petrochemical production. The ongoing reclamation on the south eastern part will offer even more space for this sector.
Built Structures
There are two important types of built structures on Jurong Island. The main typologies are the oil tanks and the chemical plants. Most of the structures are visibly connected by pipes of several sizes and give an impression of being one giant structure. These typologies are also visible on the Pulau Bukom and Pulau Sebarok islands.

Reconstructing the Map
The first step in mapping Jurong Island would be to acquire maps with the footprint and the street network. But in the case of Jurong Island, such information remains scarce. The corresponding data with the exact information are categorized as sensitive since the events of 9/11. In order to understand the island better, we used satellite pictures of different sources and years to reconstruct maps of the built structure of Jurong Island and specially to get information of the characteristics of petrochemical plants.
Maritime Accessibility

The natural conditions of the maritime territory of Singapore are one of the main reasons for the success of its port. The depths allow vessels of the Malacca class (very large crude carriers) to be served at the Port of Singapore. The new reclamation, for example in Tuas, allow even greater access to deep water zones in the land area granting more berths for large vessels.

Maritime Service Zones

The space around Jurong Island is not void. It is a highly organised space, which is mainly used for transiting and anchoring. To enter the Port of Singapore a vessel coming from the strait has to stop at a pilot boarding point. Once the pilot arrives, the vessel is under the control and supervision of the Maritime Port Authority of Singapore and guided by the port master. Because the Port of Singapore is so busy, there are several different anchorage zones for different sizes of vessels and different loads.
Jetty & Berth
Jetty is needed to transfer crude oil and oil products from a vessel to a terminal and vice versa. Every storage and refining company needs jetty to get their crude oil, while value adding downstream companies can acquire their feedstock from the refiners and the terminals. A jetty provides a pipeline connection between the tanks of the vessel and the terminal tanks. The engine of the terminal is used to pump the oil to the ship, while to get from the ship the engine of the ship is used. The depth of the berths are the most crucial quality of a jetty because they define exactly what ships can dock to the jetty and what specific amount of load they are permitted to carry.

Deaths

Jetty

\[
\begin{array}{c|c|c|c}
\text{Jetty} & \text{Berth Area} & \text{No. of Berths} & \text{Berth Length (m)} \\
\hline
\text{Totu Presentation} & \text{Barth 1: 13.2m} & 2 & 7.5m \\
\text{Barth 2: 10.2m} & & & \\
\text{Nakao Jetty} & \text{Barth 1: 15.4m} & 2 & 7.5m \\
\text{Barth 2: 12.5m} & & & \\
\text{Barth 3: 10.2m} & & & \\
\text{Barth 4: 12.2m} & & & \\
\text{Barth 5: 18.9m} & & & \\
\text{Barth 6: 8.0m} & & & \\
\text{Mobi Park} & \text{Barth 1: 13.7m} & 2 & 7.5m \\
\text{Barth 2: 14.4m} & & & \\
\text{Barth 3: 9.0m} & & & \\
\text{Coca Cola Chuen Jetty} & \text{Barth 1: 15.0m} & 2 & 7.5m \\
\text{Barth 2: 8.5m} & & & \\
\text{Barth 3: 12.0m} & & & \\
\text{Barth 4: 12.0m} & & & \\
\text{Barth 5: 15.5m} & & & \\
\text{Barth 6: 19.7m} & & & \\
\text{Barth 7: 10.0m} & & & \\
\text{SRC} & \text{Barth 1: 10.7m} & 2 & 7.5m \\
\text{Barth 2: 6.0m} & & & \\
\text{Barth 3: 12.0m} & & & \\
\text{Barth 4: 15.10m} & & & \\
\text{Barth 5: 15.5m} & & & \\
\text{Barth 6: 10.6m} & & & \\
\text{Volkswagen Terminal} & \text{Barth 1: 15.5m} & 2 & 7.5m \\
\text{Barth 2: 13.5m} & & & \\
\text{Chevron Parquet Terminal} & \text{Barth 1: 13.5m} & 2 & 7.5m \\
\hline
\end{array}
\]

Storage

The storage of oil and its products require a relatively large amount of space compared to the other functions of the island. In order to save the space of the island, the JTC Corporation is building an underground storage facility (Jurok Rock Container) with a capacity of 124,000 cbm.

Volkswagen (1-25)
TOTAL CAPACITY: 25,400.000 cbm
Sakura: 7,411,400 cbm
Weaver: 7,988,600 cbm
Kasai: 3,911,000 cbm
Petronas: 305,500 cbm
Unimak (2-3)
TOTAL CAPACITY: 25,000.000 cbm
Sakura: 7,311,000 cbm
Weaver: 6,500,372 cbm
Kasai: 4,448,000 cbm
Harbor (2-3)
TOTAL CAPACITY: 7,375,200 cbm
Chevron (0-3)
TOTAL CAPACITY: 26,000.000 cbm
Petrochemical Structures

- Oil Pipelines
- Refineries
- Cracking Plants
- Value Adding Plants

1. Refining

Crude oil reveals its real qualities when it is divided into its components. This process is called refining and is the main instrument for understanding this procedure is the refining column. Each product of this process has own qualities, but for the petrochemical sector three refining products are relevant. Liquefied petroleum gas, naphtha and gasoil are the main components that continue their way on Jurong Island for example from ExxonMobil to the Petrochemical Corporation of Singapore (PCS).

2. Cracking

Petrochemicals and Products

The main purpose of PCS is to provide the downstream companies high quality ethylene, propylene, acetylene, butadiene etc. It functions as the upstream company of the petrochemical complex on Pulau Ayer Merbau and coordinates all the supporting activities for the downstream companies.

The downstream companies take these products and produce monomers of further products but already with much higher value than the crude oil that came to Singapore by tankers. These other downstream companies complement and compete with each other. There are cases where the same two companies are competitors in one field and have supply contracts on the other side. In any case most of the products leave Singapore again by tanker.

3. Value Adding

Largest Refineries, 2012

- Refineries in Thousand Barrels per Day

- Ras Tanura Refinery, Saudi Arabia
- Port Arthur Refinery, USA
- Paragominas Refinery, Brazil

- ExxonMobil, Singapore

- SK Inpex, Japan Refinery, South Korea
- Sinopec Yangtze Refinery, South Korea
- Reliance Refineries, India
- GSI Catala Yeou Refinery, South Korea
**Gas Network**

Jurong Island, together with Senoko, is the main influx point of natural gas in Singapore. Because of the presence of the pipeline at this entry point of gas, there are also some power stations in the area.

When the submarine pipelines arrive to Jurong, the gas is transformed from high pressure to low pressure. The gas is transferred through the main pipe rack of Jurong Island to its destinations. Many companies on Jurong Island have their own power generators.

Semboor is the operator of the main pipe rack called the service corridor.

**Companies**

The JTC Corporation is putting a lot of effort to conceal the precise location of the individual companies on Jurong Island. The sites of the major companies such as refineries, storage companies and the historically relevant companies are known generally. But there are a lot of small downstream plants and supporting companies which are difficult to identify without the help of JTC Corporation.

Pulau Bukom and Pulau Sebberok are managed by Shell and Vopak respectively.
Security Aspects

Since 1971, Jurong Island is closed to the public. As the petrochemical sector became more important for Singapore, its facilities are being secured very strictly.

The maritime Prohibition Zone surrounding the island is a separation space between the shipway and the land. This zone is secured by the Singaporean Coast Guard and watchtowers manned by a private security company.

The air space is controlled by the Singapore Air Force that patrols over Jurong Island, which can change depending on the amount of risk. The use of jets for this task is more common. Sometimes there is an interval of less than 10 minutes between each jet, which means either that there is an exercise or that a special event is happening in Singapore. But even if the jet’s primary task would be to guard an event, it will always fly over Jurong Island.
Urban Uses

Jurong Island is a highly privatized and strongly secured area, there are not many urban uses present. But because there is an amount of 30,000 workers coming in on every day, there are a few uses which seem very obvious and others which are quite surprising. The expected facilities like a food court, shop or medical service are all combined in the visitor centre. Most of the companies don’t have their own canteens and have to order their food from outside of Jurong Island.

More informal uses like resting space during work breaks are found next to every bigger construction site in Jurong Island. The most unexpected facility in Jurong Island as well as in Pulasu Bukom are the dormitories for some of these workers. The dormitories on Jurong Island are quite far from the petrochemical plants while in Pulasu Bukom they are right next to the facility.
Lucite International Alpha 1 MMA Plant

Lucite International is a company specializing in the design, development and manufacture of acrylic-based products. In 2009, Lucite was acquired by Mitsubishi Rayon Co Ltd and have strengthened the position as the world’s largest supplier of Methyl Methacrylate (MMA), which is the essential building substance for all acrylics.

On Jurong Island, Lucite is using a new kind of MMA production with their Alpha 1 MMA Plant.
MMA Production Process
The feedstock for the production of MMA consists mainly of ethylene, methanol and carbon monoxide. In a first step the two intermediate products MoP and formaldehyde have to be created. Together they will react to cruelle MMA. With heat the MMA is refined and finally stored in the Vopak Banyun Terminal.

Internal Pipeline Corridor
The different reactors are all connected together by a pipe rack, which conducts the feedstock and the product, but also natural gas for the energy demand of the plant and nitrogen for fire outbreaks and explosions.

Services Provided in Jurong Island
If a company wants to rent a plot in Jurong Island, it will get 30-days rental with certain services included in the price.

The aspects that Jurong Island provides are especially the security, the pipeline service corridor and a street network based on the needs of each subsector. Of course the visitor centre contains food facilities.
Combined Layers of Infrastructures

By overlaying the main organisational aspects of Jurong Island, one can see how small the footprint of the gas facilities is compared to the oil and petrochemical sector. Nevertheless, the gas remains crucial for running the plants. So the strict separation of functions like we did it on the layers remains questionable.
Petrochemopolis

As we having analysed Jurong Island thoroughly in the previous chapter, we will now focus on the whole island-state. How is the interconnectivity between the facilities located on Jurong Island and the processing industry, support companies, logistics providers and headquarters located on the main island organized? How is this connectivity expressed spatially within the city fabric?
The Extended Enclave
Jurong island and its affiliated petrochemical sector can be seen, together with the container storage facilities and the shipbuilding sector, as an enclosed spatial entity which has a security border towards the city. Together with other non-public functions such as the military and privatized areas (airport, housing) this extended enclave establishes a border that seems to surround Singapore, introducing an inland border on the island.

The Supporting Cluster
The extended enclave needs a supporting cluster which provides special services and material that are not necessarily linked to the water. One part of the cluster is situated next to the enclave and is mainly industrial. The other part contains the office buildings and headquarters of the companies which are located next to the water.
Petroleum Cluster

The concentration of this cluster lies in the Jurong area and specially in Jurong Island, while its headquarters are within the financial center.
Chemical Clusters
These clusters are formed by the subclusters of petroleum, chemical, energy, logistics and manpower. It is defined as a highly interconnected conglomeration of companies.
The Cluster in Jurong Industrial Estate

This cluster is influenced mainly by Jurong Island, the shipyards and the logistics facilities of the container terminal and Jurong Port. More on the north there is a strip of chemical companies which is mainly composed by the Jurong Business Park, where most of the important companies of this sector have offices.
Central Business District

The central business district happens to be the major site of communication between the companies and the different sectors. Being some companies of the different sub-cluster in the same office buildings the way of communication often keeps being by telephone.
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