Chapter 2

Stockpiling Options

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CHAPTER 2

Stockpiling Options

In the crisis scenarios in Chapter 1, we saw that the oil supply could be stopped by sudden and unexpected events, causing not only economic impacts but also political and social instability. ASEAN countries use oil for a number of purposes and a disruption in the oil supply can have far-reaching consequences.

Oil stockpiling is a measure to minimise the impact of the disruption of the oil supply. Storing certain amounts of oil that are controllable in an emergency and near areas of demand could minimise the economic and social effects in the case of an oil supply disruption by allowing the immediate release of oil. This could also provide more time before necessary, more severe countermeasures (such as the introduction of a rationing system or fuel conversion) are taken.

This chapter discusses the various options for developing oil stockpiling, with the above-mentioned advantages. Section 2-1 introduces the traditional styles of oil stockpiling and explains their advantages, disadvantages, and development costs. Section 2-2 discusses the next best, lower cost options for oil stockpiling for cases where the development of full-scale oil stockpiling facilities cannot be built.

2-1 Traditional Oil Stockpiling Base Styles

2-1-1 Onshore tank base

The most typical type of oil stockpiling base is the onshore tank type. If land of a sufficient area is available, an onshore tank base is the easiest type of oil stockpiling base to develop, technologically and economically. The actual development cost depends largely on the land reclamation cost or land development cost. In a cost evaluation by Mitsubishi Research Institute for a ground tank base in Viet Nam in 2012, the cost was estimated to be US$397 per cubic metre, with a construction period of 5–6 years (Mitsubishi Research Institute, 2012). The operating expense is higher than that of other types of stockpiling facilities since an on-shore tank base requires operations such as regular inspections and stirring of the stored oil. The IEA estimates the typical annual operating expense to be US$13–US$19 per cubic metre (Stelter and Nishida, 2013).

Figure 2-1 is an aerial photograph of the Tomakomai Higashi Oil Stockpiling Base in Japan, a typical ground tank type oil stockpiling base. In many cases, onshore tank bases are constructed with many tanks in a large area, storing not petroleum products but crude oil.

Figure 2-1. Typical Ground Stockpiling Facility

Source: JOGMEC website.

An advantage of the ground tank base type of facility is that construction and operation are relatively easy. In comparison with underground storage facilities, the lower relative initial cost of construction is another advantage. In addition, since the storage facilities are placed on the ground, periodical maintenance is easy and responding to any operation troubles can easily be carried out. If the base can be constructed and operated next to a tank base of an existing refinery or oil terminal, the construction cost can be 10–20 percent lower than the construction cost of a new tank base and operation costs can be also be lower by 30–50 percent (Stelter and Nishida, 2013).

The largest disadvantage of the ground tank base is that a large area of land is necessary to construct many tanks. Local communities may also oppose the construction of an oil stockpiling base due to concerns about the scenery or perceived danger. If the land covers farmland, compensation to farmers may be necessary. An oil stockpiling base should be constructed near to a city that consumes a lot of oil so that oil can be released immediately to the city in an emergency. However, it is extremely difficult to secure land large enough to construct an onshore, tank type oil stockpiling base. It may be necessary to ask people living on the land to move to other places or to compensate them, and hence the necessary costs before construction can be high.

There is another disadvantage in that the stockpiling base is exposed to the air. This is an environmental issue. Unlike a refinery, a oil stockpiling base simply stores oil. Since there is no constant flow of oil or a high-temperature, high-pressure processing plant, the possibility of a severe accident is extremely low. However, stored oil itself is a highly combustible, dangerous material. An accident can have an extremely large impact on the neighbouring environment and local communities. Also, in the case of an oil leakage from a tank, there could be long-term, negative impacts on the surrounding nature and ecology.

High operation costs are also a disadvantage. Large stockpiling bases require regular inspection. Daily safety inspections can be costly, and the costs for electricity and heat supply are higher than for underground stockpiling bases. In some countries, safety and/or environment regulations can be strict. In these cases, the costs of complying with regulations can be high.

2-1-2 Underground stockpiling

Underground stockpiling is an oil stockpiling method to drill a solid rock bed, construct stockpiling facilities, and store oil. A typical underground stockpiling method uses a water-sealing underground tank, which confines oil using groundwater pressure. Unlike the salt cavern type of stockpiling facility, this underground stockpiling facility requires drilling of a solid rock bed, and thus requires high initial costs. The initial construction cost estimated by Mitsubishi Research Institute is US$466 per cubic metre, about 20 percent higher than that of the ground tank type. However once constructed, an underground stockpiling base requires less costs for inspection, utility, and insurance than the ground tank type, and total operation costs are lower. The annual operation cost of an ordinary underground stockpiling base was estimated by IEA to be less than US$5 per cubic metre.[4]

Figure 2-2 shows a photograph of Kikuma Stockpiling Base in Japan. This base was constructed next to a private company's refinery, whose ground tanks can be seen in the picture. The stockpiling facilities are indicated in purple and crude oil is stored in the large tunnel-like stockpiling facilities.

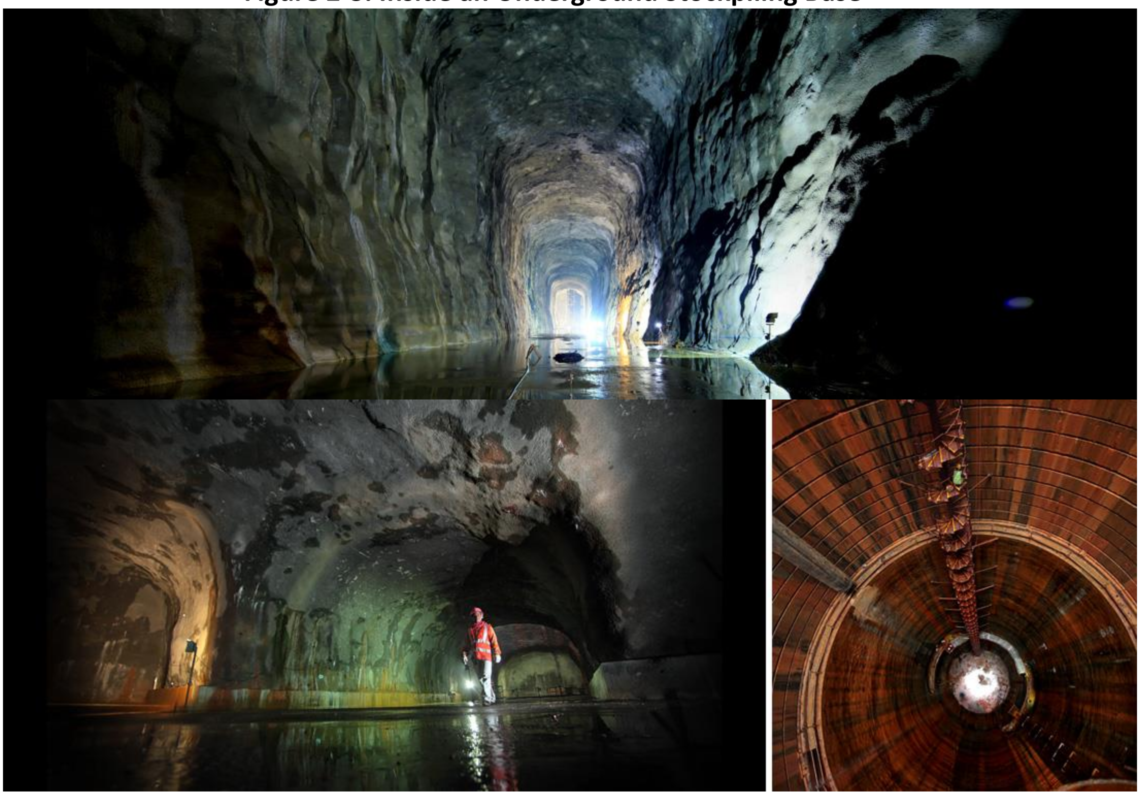
[4] Mitsubishi Research Institute Inc., Mitsubishi Heavy Industries, Ltd., JGC Plant Solutions Co., Ltd., Japan Marine Science Inc., Study on the Project for Development of National Strategic Oil Stockpiling Mega-Floating System in Vietnam (Tokyo, Japan, Oil, Gas, and Metals National Corporation: February 2012).

Figure 2-2. Image of an Underground Stockpiling Base

Note: The underground crude oil stockpiling facilities are shown in purple.
Source: JOGMEC website.

Figure 2-3 shows the inside of an underground stockpiling base in Jurong Island, Singapore, which began operations in 2014. Crude oil is stored in the tunnel-like space.

Figure 2-3. Inside an Underground Stockpiling Base



Source: JTC website.

A typical method used for underground stockpiling is water-sealing underground stockpiling. In this type of stockpiling base, a rock bed below the groundwater level is drilled to make a cavern, which then stores crude oil without having to line the cavern wall with steel or cement. Oil can be stored in the cavern because the groundwater pressure in the rock bed forms a natural wall preventing crude oil from leaking from the cavern.

Safety is an advantage of underground stockpiling facilities. The stockpiling facilities are located below the groundwater and hence crude oil stored in the cavern is confined by the pressure of the groundwater and does not leak out. Since the stockpiling facilities themselves are made of rock bed and the space above the facilities is filled with inactive gas, there is no possibility of fires or explosions. Since tanks are in the underground solid rock bed, they are also less affected by earthquakes than onshore tank bases.

There is also an advantage in terms of environmental conservation as most of the facilities are underground and hence do not ruin the natural scenery. Securing land for the underground facilities is easier than securing land for a ground tank base. This is a social advantage as people living nearby are likely to be less opposed to the base. Moreover, the operation cost of an underground stockpiling base is lower than that of a ground tank base and the rock collected from the drilling work can be used for landfilling in seaside areas. This is an economic advantage (Mitsubishi Research Institute, 2012).

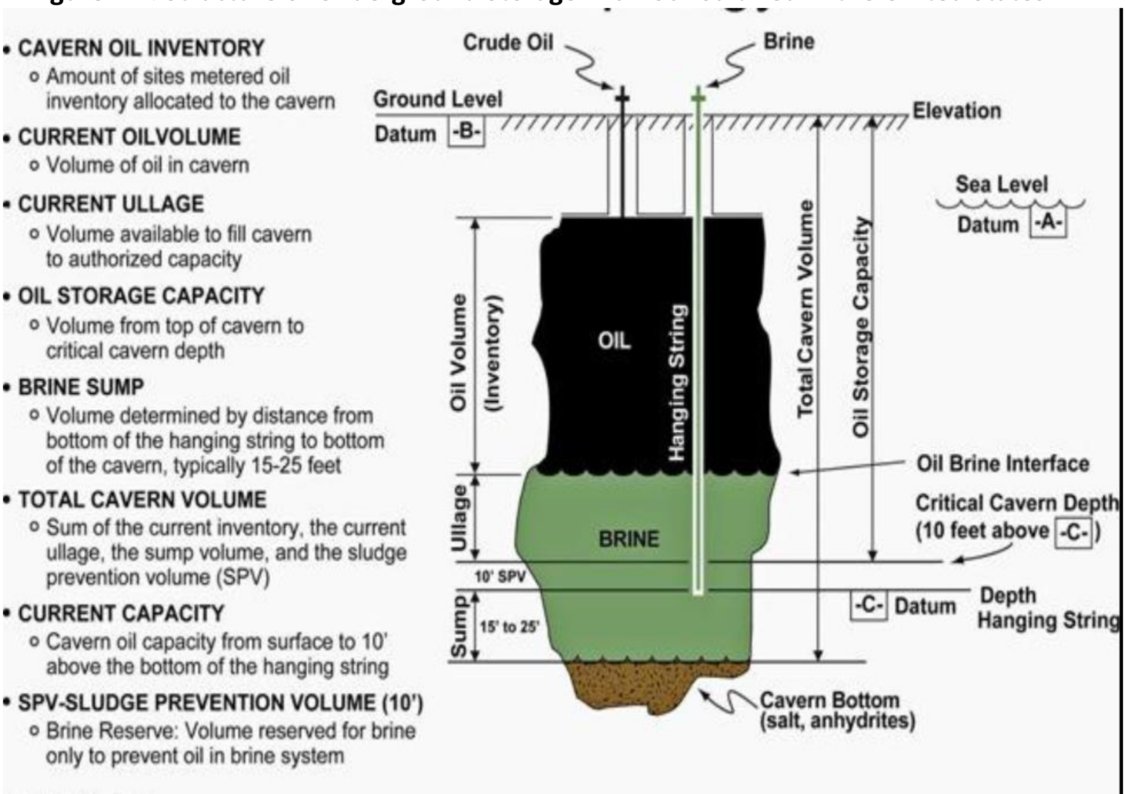
A disadvantage is that the underground facilities cannot be constructed if no appropriate rock bed is found and so the base site depends largely on geological conditions. For some geological conditions, initial costs of construction may be high. For example, Kikuma base in Japan was constructed 65 metres under the sea and the Jurong Island underground stockpiling facilities were constructed 150 metres under the sea. Their construction costs were therefore high. In order to construct water-sealing underground stockpiling facilities, which store oil by utilising groundwater streams, it is necessary to determine the location of appropriate groundwater for the facilities. If no appropriate groundwater can be found, the groundwater needs to be artificially controlled, which requires high operational costs. Compared to the ground tank type, construction of an underground stockpiling base is more difficult. Therefore, to construct an underground stockpiling base in an ASEAN country, the country may need help from a foreign company for construction. Also compared to the onshore tank type, replacement of oil stock in the underground stockpiling base is not easy, and hence bases are used mainly for the storage of crude oil, not petroleum products.

2-1-3. Stock facilities in rock salt beds

In the US, stockpiling facilities constructed in underground rock salt beds are widely used as underground oil stockpiling bases. Since rock salt beds have dense structures with extremely low porosity, the possibility of leakage of stored crude oil is extremely low. Therefore, stockpiling facilities in rock salt beds are appropriate for preventing environmental problems such as soil contamination and water pollution.

For the actual construction of storage chambers in a rock salt bed, a method called solution mining is employed. In this method, the rock salt bed is first drilled, then a large amount of water is supplied into the drilled hole to dissolve the rock salt bed and create a storage cavern. The salt water, generated when the rock salt bed is dissolved, is pressed back in the ground or discharged to the sea.

Figure 2-4. Structure of Underground Storage in a Rock Salt Bed in the United States



Source: United States Energy Information Administration website.

The greatest advantage of oil stockpiling bases in rock salt beds is the low construction costs and operation costs. As mentioned above, the stockpiling facilities are constructed not only by drilling the salt bed but also by dissolving it. Therefore the construction cost is much lower than the construction cost of simply drilling a solid bed. According to an evaluation by IEA, the construction cost is about US$75 per cubic metre, which is much lower than the costs of other types of stockpiling base. The IEA also evaluates the operation cost to be US$2.5 or less per cubic metre, which is lower than ordinary underground stockpiling bases.

Another advantage is safety. Rock salt beds are made of highly pure salt, which does not chemically react with crude oil. As such, rock salt beds are expected to work the same as steel tanks placed on the ground. There are also environmental advantages. Since crude oil is stored 600–1,200 metres deep under ground, even if a crack occurs in the rock salt bed, the underground pressure prevents the crude oil from leaking through the crack. Also, the temperature differs from place to place inside the storage cavern in the rock salt bed. It is therefore expected that the stored crude oil rotates inside the stockpiling facilities. This natural stirring effect keeps the crude oil properties in a stable state. Since periodic oil stirring is not necessary, unlike for onshore tank bases, the operation costs can be reduced.

There are few disadvantages of oil stockpiling bases in rock salt beds, but this method cannot be employed if no appropriate bed can be found. In the US, appropriate rock salt beds for oil stockpiling exist near the coast of the Gulf of Mexico, where many refineries are located. In Europe, there are also many appropriate rock salt beds for oil stockpiling. However in ASEAN countries, rock salt beds appropriate for oil stockpiling have not been found and construction of oil stockpiling bases of this type would be difficult.

2-1-4 Floating stockpiling base

Floating stockpiling bases store oil in floating tanks on the water, on the sea in many cases. Examples of the floating stockpiling bases are Kamigoto base and Shirashima base in Japan. Figure 2-5 shows an aerial view of Kamigoto base.

Figure 2-5. View of a Floating Stockpiling Base

Source: JOGMEC website.

The floating facilities can be constructed as a so-called 'mega-float' structure at a shipbuilding yard. This structure can be built only in a ship yard where a very large vessel can be built. Therefore the initial construction cost is about US$395 per cubic metre, as high as that of onshore tank bases. Since the floating base requires inspection works and management of the office building, the annual operation cost is also as high as around US$11 per cubic metre.

The largest advantage of the floating oil stockpiling base is that it is relatively easy to find a base site if the hydrographic conditions are met. If land large enough for ground tank facilities cannot be secured, a floating stockpiling base is a likely option. In particular, ASEAN countries have many islands and there are many quiet ocean areas where waves from the outer sea can be blocked. These areas are suitable for floating stockpiling bases. ASEAN countries thus have a topographical advantage. Before constructing a floating stockpiling base, it is necessary to take the appropriate measures to prevent any negative effects on local fisheries or ecological systems in the surrounding area.

Extending or moving a floating stockpiling base, if necessary for some reason, is relatively easy compared to extending or moving a ground tank base or underground stockpiling base. A disadvantage, however, is the high operation costs. In particular, if a floating base is constructed far from the coast, operation costs after the completion of the construction for operational office facilities and transportation, such as ships to go to the facilities, tends to be high. This is the largest disadvantage.

Floating stockpiling bases have to be constructed in places with appropriate hydrographic conditions. To prevent adverse weather from destroying the stockpiling facilities and causing oil leakages, the topographical conditions for the construction of a floating base have to be closely examined.

From an environmental viewpoint, a floating stockpiling base has to be constructed in a place with calm hydrographic conditions. If the stored crude oil leaks out for some reason, there could be potentially profound effects on the surrounding environment. (In Japan, to minimise this danger, protective measures with quadruple structures are taken for the bases.) From a safety viewpoint, floating stockpiling bases are weaker than underground stockpiling bases, which is another disadvantage of floating bases.

2-1-5 Summary

Table 2-1 summarises the characteristics of the four stockpiling base types. Costs to secure land change largely depend on the topographical conditions of the land. For any type of stockpiling base, preventive measures against oil leakage are assumed, but if an accident does occur, it can have significant, detrimental impacts.

Table 2-1. Comparison of Major Stockpiling Systems

	Above ground tank	Underground tank	Salt cavern	Floating tank
Characteristics	Large storage tanks above ground Globally adopted means to store crude oil Sometimes adjacent to refinery	Crude oil is sealed in the underground storage Impact to surrounding environment and scenary are limited. Conditions where sufficient underground water pressure can be maintained	Construction and maintenance cost is low. Widely adopted in US or Europe Not many locations in Asia have suitable salt layer	Facility is relatively easy to expand Large floating storage tanks offshore location
Location	Close to sea coast where tanker can moor Large flat area	Close to sea coast where tanker can moor Suffient amount of underground water to maintain crude oil in the storage	Salt dome	Calm wade and tide condition Sufficient water depth
Benefits	Easy to operate and maintenance Relatively small initial investments	Safety Environmentally friendly No need to secure wide surface land	Low initial investment and operating expenses	No need to find a wide surface land Easy to transport
Drawbacks	Difficulty to find suitable land Relatively high OPEX	High initial investment Difficult to find suitable geological condition	Dificult to find suitable geological condition	High operating expenses Risk of oil spill
Requried land area	Large	Middle	Small	Small
Environment impact	Big	Middle	Small	Small
Construction period	5-6 years	7-10 years	7-10 years	3-4 years
Construction unit cost	USD 397 / m3	USD 466 / m3	USD 75 / m3	USD 395 / m3

Note: Because cost estimates of each type refer to different sources, the basis assumptions may be different across types. The costs shown in the table are the construction costs only and do not include operational expenses or procurement of stockpiled oil.

Source: Mitsubishi Research Institute, International Energy Agency, complied by IEEJ.

2-2 Lower-Cost Options

For securing the oil security of a nation, the final goal is to develop oil storage within the country. However, many of the ASEAN countries are still undergoing economic development and do not have the required financial resources to construct oil stockpiling bases on a significant scale. Therefore, while aiming for the long-term development of oil stockpiling bases as described in the previous sections, these countries may choose lower-cost stockpiling options to enhance oil security as much as possible until the future development of stockpiling bases is completed. The following section examines the options for low-cost oil stockpiling.

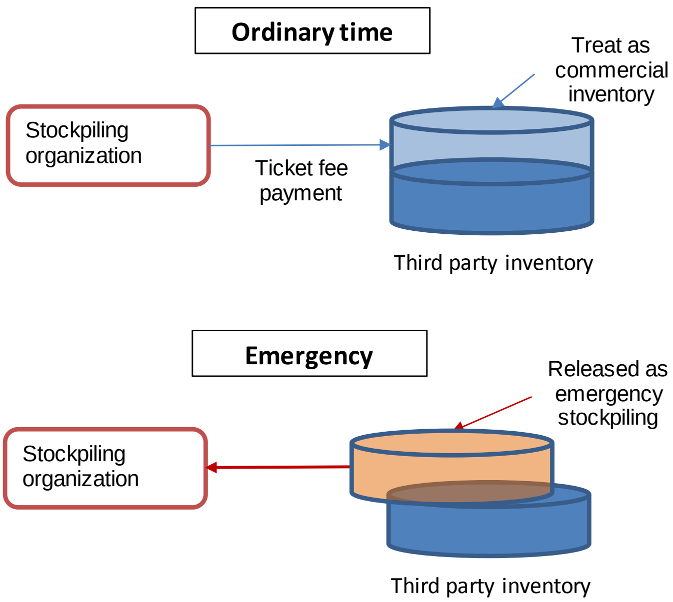
2-2-1 Ticket stockpiling

(1) Outline

One low-cost option of oil stockpiling is stockpiling by ticket, which is most commonly used in Europe. Ticket stockpiling is a system in which a country's agency in charge of oil stockpiling pays a ticket fee (charge for oil stockpiling) to count oil stock held by other agencies as emergency oil stock. 'Other agencies' include domestic oil companies, domestic oil stockpiling agencies, and foreign entities. In this system, the agency paying the ticket fee does not have actual oil stock but entrusts oil stockpiling to other agencies. If the ticket stockpiling is entrusted to an oil company, the company receiving the ticket fee has to store the designated inventory of oil during ordinary times. The company can use the oil for business in ordinary times but needs to release the oil in the event of an emergency.

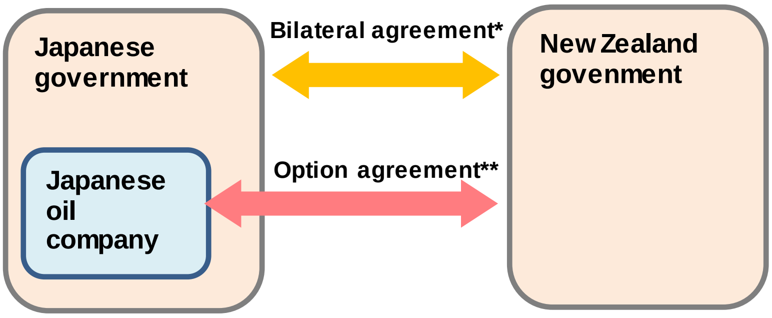
If the ticket stockpiling is conducted between two countries, both governments make an agreement on the stockpiling of a specific amount of oil before agencies in the two countries actually make a contract. For example, for ticket stockpiling between Japan and New Zealand, the governments of the two countries first made an agreement, and then a Japanese oil company and the New Zealand government made a ticket contract that New Zealand would pay a ticket fee and the Japanese oil companies would promise to supply petroleum products to New Zealand in the case of an emergency.

Figure 2-6. Forms of Ticket Stockpiling



Source: The Institute of Energy Economics, Japan.

Figure 2-7. The Ticket Stockpiling System between Japan and New Zealand



***Bilateral agreement**
- Inventory for option contract is counted as stockpiling volume of New Zealand.
- When New Zealand exercises its option contract, Japan does not obstruct transportation of the stockpiling volume.

****Option agreement**
- New Zealand government purchases option to buy oil from Japanese oil company through option fee payment.

Source: The Institute of Energy Economics, Japan.

The ticket stockpiling system has been widely used in Europe. In East Asia, New Zealand has already introduced the system. Many countries have set the upper limit of the ticket stockpiling to be 10 percent of the total required oil stock for security reasons.

(1) Advantages

The largest advantage of the ticket stockpiling system is that actual storage of oil is not necessary. For energy security, it is important to construct oil stockpiling bases, but construction costs are extremely high. Therefore, ticket stockpiling can minimise the costs for the development of oil stockpiling facilities. By having an external oil stock as a ticket, one does not have to store oil or conduct the operational work necessary for the stored oil. The system also has the advantage that the security and safety risks of having oil stock can be avoided.

Another advantage is the economic rationality. In stockpiling oil, it is rational to store the oil where storage costs are lowest. For ticket stockpiling, the agency in charge of oil stockpiling in the country that is buying the ticket calls for bids on oil stockpiling to determine agencies selling the ticket. Through this process, the agency in charge can entrust stockpiling and operations of oil to the most cost-competitive agency.

The third advantage is high flexibility. Once oil stockpiling bases are constructed in a country, the number of bases cannot be easily changed depending on the balance between oil demand and the oil market. However, the amount of oil stored by the ticket stockpiling system can be relatively easily changed at the end of the contract. If the domestic demand is expected to change considerably in a short period of time or if parallel development of multiple oil stockpiling bases is expected, the ticket stockpiling is an effective choice because the oil stock amount can be changed. However, this flexibility also has a disadvantage. In order to be able to buy a ticket at an arbitrary time, there needs to be excess stockpiling facilities or excess stock somewhere in external agencies. If only a small capacity of oil storage is available, there is a risk of an increase in the ticket price.

Table 2-2. Major Countries that have Introduced Ticket Stockpiling Systems

Country	Domestic tickets		Tickets abroad	
	Allowances	Usage	Allowances	Usage
Australia	Not applicable		Not applicable	
Austria	Not allowed		Not allowed	
Belgium	Allowed	Yes	30% of public stocks	Yes
Canada	Not applicable		Not applicable	
Czech Republic	Not allowed		Not allowed	
Denmark	Allowed	Yes	30% of obligated industry stocks and 5% for FDO	Yes
Finland	Allowed	*	20% of obligated industry stocks	No
France	Allowed	Yes	Allowed	No
Germany	10% of EBV's stockholding obligation maximum	Yes	10% of EBV's stockholding obligation maximum	No
Greece	Not allowed		Not allowed	
Hungary	Not allowed		Not allowed	
Ireland	Allowed	No	Allowed	Yes
Italy	Allowed	Yes	Allowed	Yes
Japan	Not allowed		Not allowed	
Korea	Not allowed		Not allowed	
Luxembourg	Allowed	No	Allowed	Yes
Netherlands	Allowed	Yes	Allowed	Yes
New Zealand	Allowed	No	Allowed	Yes
Norway	Not allowed		Not allowed	
Poland	Allowed	*	5% of obligated industry stocks, not allowed for ARM	No
Portugal	Allowed	*	Allowed	No
Slovak Republic	Not allowed		Not allowed	
Spain	Allowed	Yes	Allowed	No
Sweden	Allowed	Yes	20% of obligated industry stocks	Yes
Switzerland	Not allowed		Not allowed	
Turkey	Not allowed		Not allowed	
United Kingdom	Allowed	Yes	Allowed	Yes
United States	Not applicable		Not applicable	

Note: * Information on the use of domestic tickets in Finland, Poland and Portugal was not available at the time this paper was drafted.

Source: International Energy Agency, 'Focus on Energy Security'.

(2) Challenges

A challenge in the promotion of the ticket stockpiling system is the incentive of a country to store oil. All the countries employing the ticket stockpiling system, shown in Table 2-2, are IEA member countries and possess an obligation of 90 days' worth oil stockpiling. IEA member countries have a duty to have oil stockpiling, no matter what oil type is stored or where or how it is stored among the member countries. Therefore, if a similar arrangement were introduced in ASEAN, it would be preferable for ASEAN to have a similar obligatory framework in place to stockpile oil.

Another challenge is the geographical distance to the stockpiling base of a ticket. In Europe, even when a stockpiling base owned by a ticket is located outside the ticket holder's country, the country often has a pipeline to the base and the line is often not very long. Therefore, when the country needs the stored oil in an emergency, it can secure the oil in a reasonably short period of time. In ASEAN, on the other hand, if a country buys a ticket from another country, the distance to the oil stockpiling base may be very long and in many cases the oil may need to be transported by tankers, depending on the relevant countries. Therefore, mobility of oil is a large problem for effective stockpiling by tickets.

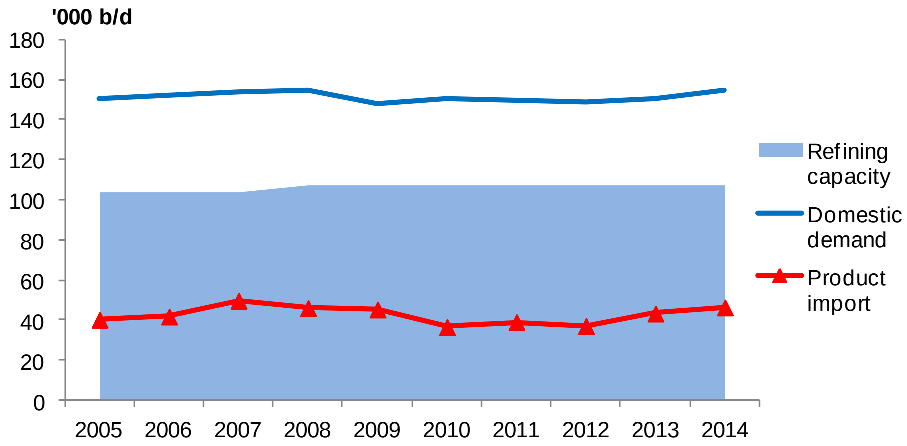
Accurate and transparent data is also an important issue because a ticket holder needs to ensure that the ticketed volume is readily available. This requires strong trust been ticket holders and ticket issuers in such arrangements.

For oil stockpiling by ticket, it is necessary in many cases to find an oil company that owns stock facilities of a sufficient size that can afford to lend part of their facilities. When there is a loose supply-demand balance, and in particular when contango is observed in the futures market, oil companies carry a lot of stock and can easily provide some of the stock for ticket stockpiling. However, in the case of a tight supply-demand balance, it can be difficult to find an oil company possessing the necessary oil stock. In general, private oil companies have an incentive to hold as little commercial oil stock as possible. Therefore, the ticket price has to be high enough to encourage the companies to hold more oil stock and supply oil from their stockpiling facilities. Hence, the ticket price or available volume may change largely depending on the status of oil stock in the market.

(3) Case study of New Zealand

New Zealand is the only country in the Asia-Pacific region that uses the ticket stockpiling system. The domestic oil demand, refining capacity, and oil product imports in New Zealand are shown in Figure 2-8. Domestic oil demand increased continually after 1980, but reached a peak in 2005, staying at around 150,000 b/d.

Figure 2-8. Domestic Oil Demand, Refining Capacity, and Oil Product Imports in New Zealand



Source: BP (2015); IEA Energy Balances of OECD Countries.

Oil production in New Zealand is around 35,000 b/d (as of 2013) and most of the oil is produced in the Taranaki Basin, offshore and to the west of the North Island. The crude oil produced in this oil field is light, low sulphur crude oil, which can be sold at a high price in the international market. Most of the oil produced is exported.

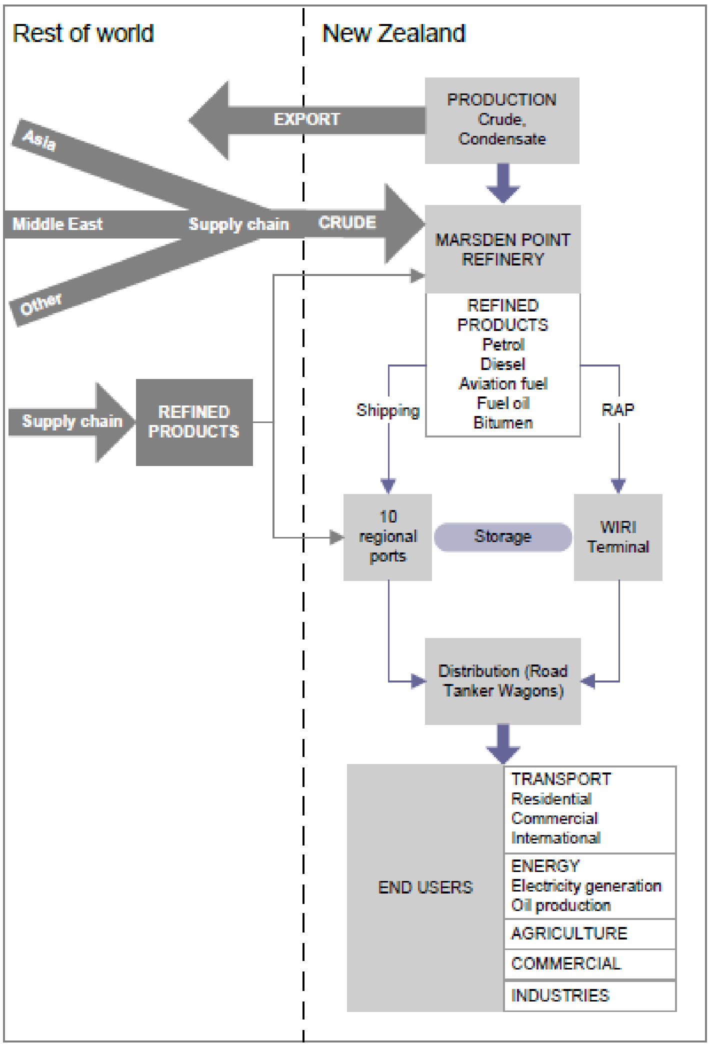
Figure 2-9. Oil Infrastructure in New Zealand

Source: International Energy Agency (2014).

New Zealand has only one refinery, located in Whangarei in the northeast of the country. Its refining capacity was 107,000 b/d as of 1 January 2016. The refinery supplies 80 percent of the petroleum products in New Zealand. Petroleum products are also imported from Singapore and Korea, with imports from the two countries accounting for almost 90 percent of all imports. Forty percent of the crude oil refined in the Whangarei refinery comes from Middle Eastern counties, especially from Saudi Arabia and Qatar. The rest comes from Asian countries, such as Malaysia and Brunei Darussalam.

Figure 2-9 shows the oil supply structure in New Zealand. Most of the crude oil produced in the country is exported and crude oil is imported from the Middle East and Asia to the refinery, which produces 80 percent of the petroleum products supplied in the country. The produced products and imported products are supplied to filling stations (SS) in various places through petroleum product pipelines and the domestic logistics network.

Figure 2-9. Oil Flow in New Zealand



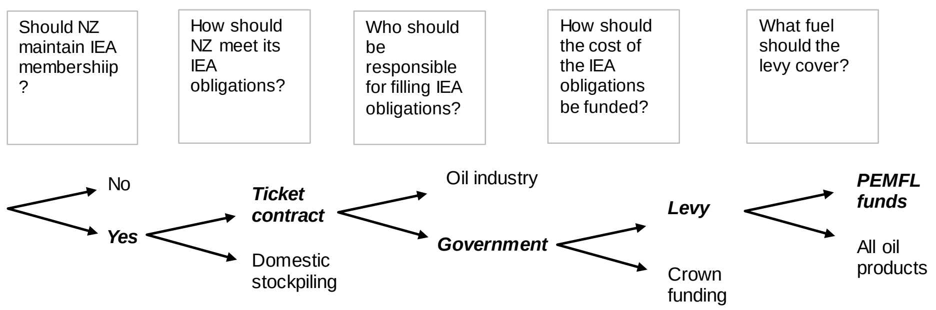
Source: Ministry of Business, Innovation, and Employment (2012).

Since New Zealand is an oil-producing country, it used to be able to meet the IEA's 90-day target from only the commercial oil stocks of private oil companies. However from the mid-2000s onward, demand has increased and domestic production has reduced, so the country was no longer able meet the target using only commercial stock. New Zealand therefore began oil stockpiling by ticket on 1 January 2007 to achieve the IEA target. It accepts international bidding to secure oil stock every year and buys ticket contracts to purchase stored crude oil or petroleum products from foreign countries, such as the Netherlands, the United Kingdom (UK), and Japan. Based on the ticket contracts to purchase oil, New Zealand can require the ticket-issuing countries to release some, or all, of the ticketed stockpiled oil in the event of an IEA collective action. The release, however, is not automatically done when the IEA decides collective action. The ticketed volume is released only when New Zealand requires the ticket issuing countries to do so.

New Zealand has had a high interest in oil security for several reasons: the crude oil produced in the country has not been enough to meet domestic demand; most of the produced crude oil is exported and most of the oil supplied to the country is imported oil; and the country is located far from other countries so it is not easy for New Zealand to rely on other countries for receiving oil supplies in an emergency.

Based on such heightened interest in oil supply security, the Ministry of Economic Development of New Zealand issued a report on oil security in 2005[5]. In this report, option analysis was conducted to reach the conclusion that ticket stockpiling based on government funds is the best option for New Zealand. This report first asks whether New Zealand should maintain its IEA membership, as that is its biggest motivation for developing stockpiling. The report explains that the country should maintain the membership as it brings numerous benefits, such as information sharing about oil markets, technological expertise in the use of other forms of energy, as well as opportunities for exchange on various issues of energy policy with other advanced countries.

Figure 2-10. Option Analysis for Stockpile Holdings



IEA = International Energy Agency, NZ = New Zealand, PEMFL = Petroleum or Engine Fuel Monitoring Levy.
Source: Ministry of Business, Innovation, and Employment (2012).

[5] Covec and Hale and Twomey Limited, *Oil Security* (Wellington, Report prepared for Ministry of Economic Development), 2005

The report then asks whether New Zealand should construct a stockpiling base or adopt ticket stockpiling. It claims that the country should choose the ticket stockpiling option, as it is more economical than building a stockpiling base. The cost-benefit analysis on the construction of an oil stockpiling base and oil stockpiling by ticket was conducted in another report entitled *New Zealand Oil Security Assessment Update*, published in 2012. The report shows that the construction cost of a new oil stockpiling base would be US$10.88–US$14.25 tonnes per month and the cost of ticket stockpiling, estimated from past examples, would be US$0.79–US$1.86 tonnes per month. The report therefore notes that the construction of a new stockpiling base is not an economically appropriate option. The report also explains that stockpiling should be developed by the government, as industry does not have the sufficient capability to pursue such high-cost investment. The report concludes that the cost of the stockpiling arrangement should be levied on oil consumers, as oil users should bear the cost of stockpiling, too.

Based on the findings, New Zealand made intergovernmental agreements with the UK, the Netherlands, Spain, Japan, and Denmark, and has been bought tickets from the Netherlands, Spain, and Denmark, as of March 2016. Although the ticket prices have not been disclosed, volatility has been extremely high and prices fell to one-sixth over the period from 2009 to 2016. The New Zealand government has secured NZ$3 million on average every year, which has not enough in some years (Ministry of Business, Innovation, and Energy, 2015). The government raised its Petroleum or Engine Fuel Monitoring Levy (PEFML) of 0.045 cents per litre imposed on major petroleum products, such as gasoline and diesel oil, by 0.2 cents to secure the required financial resources.

New Zealand, as shown above, decided that ticket stockpiling is the best option for the country's stockpiling based on thorough examination of the various options and rigorous cost-benefit analysis. The country's approach will be a good reference for ASEAN countries in considering how to develop their own stockpiling systems.

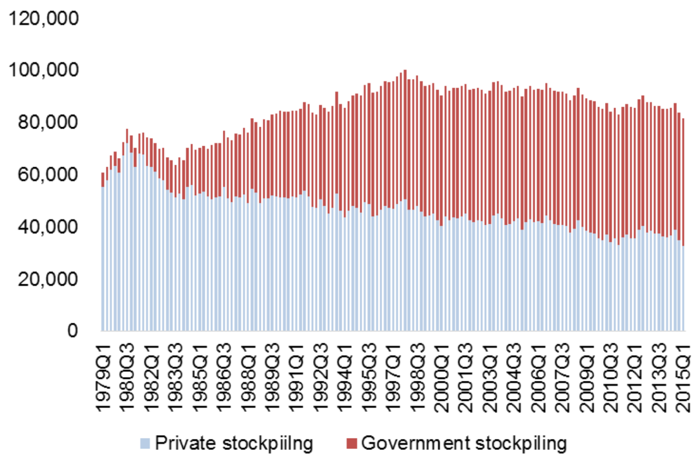
2-2-2 Upgrading of commercial stock to stockpiling

(1) Outline

Another lower-cost option is to upgrade the existing commercial stock to stockpiling by setting obligations. As this would simply impose a minimum inventory on existing players, it is the easiest option from an administrative standpoint. Of course, since many oil companies keep their stock as low as possible for business efficiency, they would have to construct additional storage facilities in addition to those used for storing the minimum necessary amount of oil for business. The government would need to create a legally binding regulation for oil companies to stockpile a certain amount of oil. In many ASEAN countries, national oil companies manage the domestic oil business. Therefore, it would be relatively easy to require an increase in oil stock from those companies than private companies.

Japan is one of the countries that have increased oil stockpiling in this way. After experiencing the oil crisis in 1970s, the Japanese government began to develop oil stockpiling for emergencies. First, the government obliged domestic oil companies to consider a part of their stock as stockpiling for emergencies and keep a certain level of oil stockpiling. As national oil stockpiling bases were constructed and completed, the obligations by companies were gradually loosened. (Figure 2-11). Since this new regulation imposed a heavy burden on private companies, the Japanese government needed to financially support the companies to increase stockpiling. The details are described in Chapter 3.

Figure 2-11. Amount of Stockpiled Oil in Japan



Source: Institute of Energy Economics, Japan.

Obligations for government-run or private domestic oil companies to stockpile commercial oil have been gradually promoted in ASEAN countries. Table 2-3 shows these activities. These existing obligations will be a good start for further expanding the obligatory volumes.

Table 2-3. Stockpiling Obligations in ASEAN

Country	Stockpiling Obligation
Singapore	Power plants and fuel suppliers are obliged to respectively have 60 and 30 days' worth of fuel oil stockpiling for electricity
Thailand	Oil companies are obliged to have 25 days' worth of oil stockpiling
Philippines	Refining agents, bulk marketers, and liquefied natural gas importing companies are obliged to respectively have 30, 15, and 7 days' worth of oil stockpiling

Source: Institute of Energy Economics, Japan.

(2) Advantages

Upgrading of the existing commercial stock to stockpiling has many advantages. Since there is already existing infrastructure, such as tanks, facilities for lifting and loading cargo, and pipelines for oil supply, the cost to construct additional storage facilities is very low. Cargo handling facilities for commercial use during ordinary times can also be used for releasing stockpiled oil, which would be efficient and effective for the oil release. When releasing oil from independent, government-run stockpiling facilities, handling facilities that are not used in ordinary times would need to be used and hence require some preparation. However, if existing facilities are extended to hold stockpiling, oil release in an emergency can be made at an appropriate time because the facilities usually used for commercial operation can be used for the oil release, and the released oil can be transported through the usual oil transport paths.

Also, existing facilities and workers can be efficiently used for operations. Since electric power and heat from the existing facilities can be used, use of the existing facilities has a large advantage compared to construction of new stockpiling facilities. There is also a large advantage from the viewpoint of facility security control and environmental conservation as workers at a refinery or import base can be used for cargo work and safety inspections of stock facilities.

In addition, operators with knowledge of the existing facilities can assist in procuring oil and materials for construction of the facilities. Additional oil stockpiling requires the procurement of oil at a competitive price. Such procurement can be conducted based on the knowledge accumulated by the operators through their experience and knowledge of ordinary commercial trade.

(3) Challenges

The biggest challenge is encouraging the oil industry, which owns the stock infrastructure, to expand its facilities. Establishing a relationship with the oil industry for oil stockpiling is therefore an important issue, which will be discussed in detail in Chapter 3. Problems must be solved, such as how to introduce legal obligations, or what incentives should be developed for taxation or financial support from the government.

Another challenge is ensuring the arrangement works properly. Development of an accurate and timely statistical data collection system is necessary for checking that the required minimum inventory is maintained. Detailed procedures on releasing stockpiles must also be agreed upon to determine who decides when and what volume of oil will be released. If the number of stockpiling inventory holders becomes large, the procedures will become more complex.

2-2-3 Third-party leasing stockpiling

(1) Outline

Third-party leasing stockpiling is an arrangement where a third party lends storage capacity and uses it for commercial purposes in ordinary times; but the capacity owner (in many cases the host government) can claim prioritised access to the inventory in the storage as a part of stockpiling. Since the possibility of the occurrence of an emergency requiring oil release is extremely low in reality, the fee for leasing the facilities as commercial oil stock facilities can compensate the cost of developing the facility and its operation in ordinary times.

Japan utilises this method as its third type of stockpiling, together with national stockpiling and private stockpiling and conducts the arrangements with major oil producing countries. Saudi Aramco, Saudi Arabia's national oil company, and Abu Dhabi National Oil Company, Abu Dhabi's national oil company borrow stockpiling facilities in Okinawa and Kagoshima prefectures, respectively, for crude oil sales in the Asian market. The Japanese government and the governments of the two countries agreed that the oil companies in the two Arabian countries could use the stockpiling facilities for business in ordinary times and the stockpiled oil would be released to the Japanese market on a priority basis in emergencies.

(2) Advantages

An advantage of this method is that the country possessing the stockpiling facilities can recover some of its operating expenses by receiving a leasing fee. In principle, oil for stockpiling is just stored and does not produce a profit by itself. However, revenue can be acquired by leasing the oil stockpiling facilities to a third party with an obligation to release the stockpiled oil in an emergency.

Since the stockpiled oil is used for business, the oil is not simply 'stockpiled' but 'flows.' Therefore, the quality of the stockpiled oil can be maintained in this flowing stockpile. Although the quality of crude oil does not degrade during long-term storage, the quality of petroleum products tends to degrade after several years. By increasing the flowing stockpile through collaborative stockpiling, the oil is regularly replaced and its quality can be maintained.

Also, as in Japan, collaborative stockpiling with major oil supply countries can strengthen the relationship between countries. For Japan, Saudi Arabia and the United Arab Emirates are the largest and second-largest oil supplying countries. Therefore, even in the case of an emergency, crude oil from these countries can be processed at domestic refineries without worrying about the quality of the oil.

(3) Challenges

One problem of collaborative stockpiling with a third-party country is that the capacity of the facilities has to be large enough for the third party to use. Construction of a stockpiling facility requires a large amount of capital, and thus any firm agreement for such third-party leasing has to be agreed before constructing the facility. Therefore, private companies may be wary in investing in such facilities and the government needs to play an important role in their construction.

For collaborative oil storage, such as that conducted by Japan and Saudi Arabia or the UAE, the commercial advantage of storing crude oil is a key issue. For example, the facilities in Japan are geographically close to China and Korea, i.e., large markets for Saudi Arabia and the UAE, which is an incentive for oil-producing countries to store oil in Japan for commercial purposes. In order for the oil-producing countries to store oil in ASEAN countries, the countries have to be attractive as an oil market for the oil-producing countries.

Also, it must to be made clear in advance on what standard the stockpiled oil is released in. This is because stockpiled oil is not actually released unless the third party that owns the stockpiled oil agrees on the conditions of the release.

2-2-4 Regional stockpiling

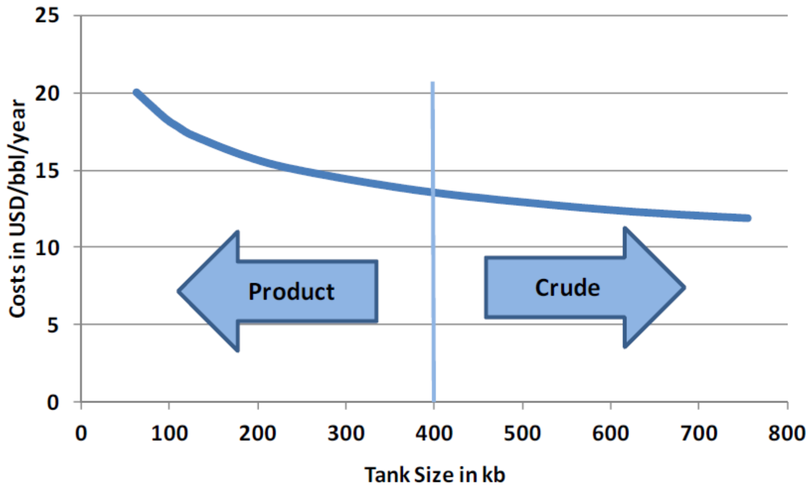
(1) Outline

Regional stockpiling is oil stockpiling based in a specific location that countries in the region can access in an emergency. Constructing such a regional collaborative stockpiling base would be beneficial for the ASEAN region. Stockpiling would be held and operated under the control of a specialised organisation, supported by investment from ASEAN member countries.

(2) Advantages

The greatest advantage of regional collaborative stockpiling is that it can benefit from economies of scale. According to an evaluation by the IEA, a 0.1 million-barrel tank of and a 0.4 million-barrel tank have a cost difference of at least 25 percent (Figure 2-12). Therefore, it is economically rational to build an oil stockpiling base together in a certain location rather than to build small bases in multiple countries with small oil demand.

Figure 2-12. Size and Construction Costs of Oil Storage Tanks



Source: International Energy Agency, 'Focus on Energy Security'.

Regional stockpiling also has the advantage that the various resources of the countries in the region can be pooled and shared for effective and efficient operation of the oil stockpiling. If each country invests money to establish a stockpiling facility, it needs to establish a specialised organisation with permanent staff and operate the facility by itself. If countries can establish a common organisation for stockpiling, they can pool their staff and financial budgets, and utilise them in a more efficient manner. Analysis of oil supply and demand, for example, can be done more efficiently by gathering human and information resources in a single place.

Some ASEAN countries may not have the capacity to develop and operate their own stockpiling bases, but by forming a regional organisation and stockpiling facility, they may have access to stockpiling by becoming partial investors.

The most suitable place for this type of stockpiling in ASEAN would be Singapore. As seen in Chapter 1, Singapore is a trade hub in the Asian oil market, possessing stock facilities of a capacity of 9 million kilolitres. It is also located in the centre of ASEAN. From Singapore, oil can be transported to any ASEAN country within a week. It is also easy in Singapore to find tankers for the transport of petroleum products in an emergency and the country politically and economically stable.

(3) Challenges

The first large challenge for advancing this type of oil stockpiling is that from a security viewpoint, some countries may not agree on stockpiling their oil in another country's territory. It can be expected that many countries consider oil stockpiling to be an important aspect of oil supply security, and would therefore want their stockpiled oil to be located in their own countries. To advance this regional stockpiling, strong relationships and mutual trust among the countries has to be built.

Even if an agreement on regional stockpiling were to be made, the location of the stock would be another issue. Singapore seems to be the most appropriate in terms of stockpiling infrastructure among the ASEAN countries. However, it is far from the Philippines, which may not be able to use the stored oil immediately in an emergency. This issue may also raise a free-rider problem. If a country's facility is identified as a regional stockpiling facility and the burden of its operation and maintenance is taken on by the country, it may feel that the other countries are free-riders of the stockpiling system, making the agreement unsustainable.

The details of the organisation must also be decided, such as the ratio of investment, the organisation's decision-making process, how to secure oil, who operates the stockpiling base, and the form of oil stockpiling. Administrative procedures will also be complicated, as detailed operational rules, such as the definition of an emergency and decision-making procedures, need to be developed.

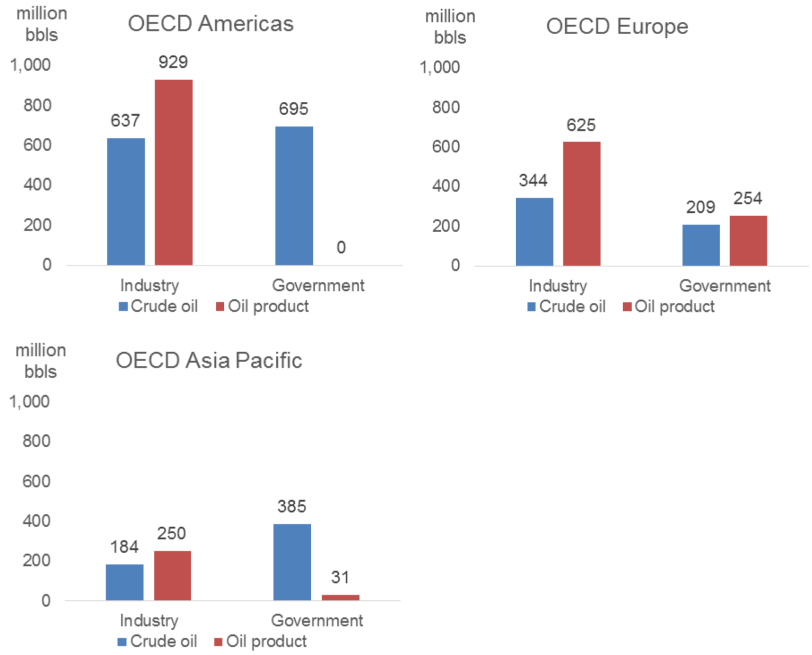
Another problem is the quality of the stockpiled oil or petroleum products. Refineries in the ASEAN area refine crude oil from different oil-producing countries and hence have to stockpile various types of crude oil. Also, many ASEAN countries employ the Euro Standard of petroleum product quality, but standards vary among countries. Coordination of the quality differences must therefore be conducted.

2-2-5 Multilateral arrangement system

(1) Outline

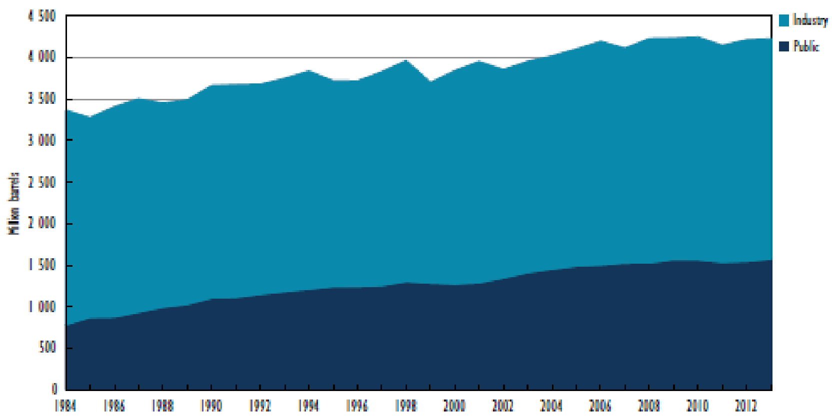
A multilateral arrangement system is a cooperative framework where multiple countries agree to share their oil with each other if a serious oil disruption occurs. When oil supply termination occurs at a certain level in one of the member countries, the other countries must collaboratively supply oil to the affected country. A precondition for the operation of this oil sharing system is that a certain number of member countries must have developed oil storing infrastructure and hold enough oil stockpiling to respond to a certain level of supply change. Also, the countries need to have infrastructure for not only domestic oil supply but also for exporting to foreign countries.

Figure 2-13. Oil Stock of International Energy Agency in Different Regions (as of October 2015)



Source: International Energy Agency, Oil Market Report.

Figure 2-14. Oil Stock of the International Energy Agency



Source: International Energy Agency (2014).

As an example, ASEAN countries agreed to the ASEAN Petroleum Security Agreement (APSA) in 2009, however it is yet to be exercised.

(2) Advantages

An advantage of a multilateral framework is in minimising the impact of a disruption by pooling the stockpiling of the member countries. Oil supply disruptions can occur for various reasons.

If the Hormuz Strait were to be closed, many oil importing countries would be affected and the multilateral sharing system may not work. However, for oil supply disruptions that largely affect a specific area, such a hurricane in the US or the supply termination of Libyan crude oil, which is exported mostly to Europe, additional supply from areas that are not affected would be extremely effective. Therefore, a multilateral sharing system is more effective with a larger number of member countries.

Another advantage of the multilateral framework is information sharing. For example, the IEA regularly releases the latest information on the demand-supply situation in the current oil market, expectations of the future demand-supply balance, the risks in the current oil market, and measures necessary to minimise the influence of the risks. It also regularly reviews the oil supply security policies and other energy policies of individual countries to find problems and promote sharing of the best practices of the countries. Therefore, an advantage of the multilateral framework is to provide a system for information sharing and the formation of collaborative relationships among regions on the energy security and energy policies based on the system.

(3) Challenges

A challenge in developing such framework in ASEAN is that ASEAN, unlike the IEA, has countries with largely differences in their stages of economic development, oil demand-supply situations, and views on oil security. Therefore, the greatest problem in the development of a multilateral sharing system is to unify countries with a variety of attributes and policies in a single framework.

First, it is necessary to set up a permanent secretariat for the development of a multilateral sharing system, like the IEA. This is because an organisation for coordination among member countries and market analysis is necessary before taking actual, coordinated action. For market analysis, specialists who can regularly analyse trends in the oil market and personnel to collect and analyse statistical data and price data are also needed. For this coordination and analysis work, a permanent organisation is necessary, giving rise to the problem of who must pay for the costs. A large challenge in the execution phase may be in determining the cost sharing among member countries.

For ASEAN countries, the existence of APSA is an important asset for future development of a multilateral framework. Currently, ERIA is examining the operation of the system with expectations of practical achievement.

2-3 Summary

This chapter summarised the advantages and challenges of various options for oil stockpiling. In practice, the best type is often determined by eliminating the inappropriate options based on a country's limitations (budget restrictions, topographical and geological conditions, securing of land, etc.) and political priorities (emphasis on higher security or economy, accepting or rejecting foreign capital, etc.) For the early development of an oil stockpiling base, the restrictions must be solved one by one.

The construction costs, advantages, and disadvantages of each stockpiling base type explained in this chapter are the most common ones. In the actual development of a base in an ASEAN country, there may be further costs, advantages, and disadvantages specific to the country.

The five low-cost options may also be combined in actual applications. For example, regional stockpiling may be combined with a ticket stockpiling arrangement. This would be a practical choice, because in many cases, ASEAN countries lack the sufficient land and financial capabilities for building their own stockpiling bases, and this would allow them to enjoy the benefits of economies of scale and the accumulation of market information and operational expertise.

Table 2-4. Comparison of Lower-cost Stockpiling Options

	Ticket	Upgrading commercial inventory	Third party leasing	Regional stockpilnig	Multilateral arrangement framework
Characteristics	Stockpiling arrangement where an entity that is responsible for stockpiling pays a fee (or purchase a ticket) to another entity to claim a certain volume of oil as its stockpiling. Ticket can be purchased from both domestic and international entities An entity that receives the ticket fee has to provide the ticketed volume if requested by the ticket holder.	Setting an easier target to the existing commercial inventory holders and gradually raising the target preferably with the government's support	Stockpiling storage leased to a third party for commercial use in ordinary times; but the storage owner can claim the prioritized access to the inventory in the storage in case of emergency.	Multiple countries agree to have a single stockpiling base and store their oil in the base. Each country can claim the stored inventory in case of emergency.	Multiple countries agree to arrange and coordinate their inventory in case of emergency. Combining obligation of stockpiling development with the arrangement will be more effective.
Benefits	- No need to hold physical inventory - No capital expenditure for stockpiling facility and no operational expenses for stockpiling - No risk of accident that may occur at stockpiling facilities - Higher flexibilities, particularly grade and volume of stockpiling	- Capital expenditures and operational expenses can be saved by utilizing an existing infrastructures. - Actual release of stockpiled oil can be smoothly done because the release will use the current operating infrastructure and staffs. - Expertise of commercial operators can be utilized.	- Operation costs of stockpiling can be made up with additional revenues - Stored inventory is usually used for commercial operations: it can avoid quality degradation of by storing oil for a long time.	- Economies of scale Concentrate various resources and utilize them in an effective and efficient manner. - Countries with different development stage and economic background can have a stockpiling by joining efforts with other countries.	- An established and operational example exist (IEA's arrangement) - Pooling inventory and arranging each other in case of emergency can enhance supply security and resilience. - Information sharing helps the member countries to promote stockpiling development.
Challenges	- Geographical distance from stockpiling base may be a serious problem - Availability of appropriate ticket issuers has to be ensured. - Ticket price may be volatile. - Security concern for not holding physical inventory	- Incentivizing the commercial operator is not easy. - Government's support may be needed. - Acquisition of additional land for such stockpiling facilities may be difficult	- Finding an appropriate partner for joint stockpiling is sometimes difficult. - Monitoring and ensuring a certain level of inventory is difficult. - Need to clarify the conditions of the release in advance.	- No existing arrangement - Security concern to have a stockpiling outside the country - Selecting the location may be politically complex. - Administrative cost is large.	- Making agreement among countries with very difference economic development stage, oil market size, and the level of inventory, is not easy. - Permanent secretariat needs to be set up.
Remarks	- Extensively utilized in Europe - Ticket price as of year 2015 is less than USD1.0/ton/month	- Easiest way to build stockpiling from the government standpoint - Government may ensure that the inventory passes the incremental cost to the final selling price.	- Japan and Saudi Arabia and UAE have this type of stockpiling arrangement.	- Combining with ticket stockpiling can be an effective arrangement.	- APSA will be the appropriate platform if this type of stockpiling aims to be realized

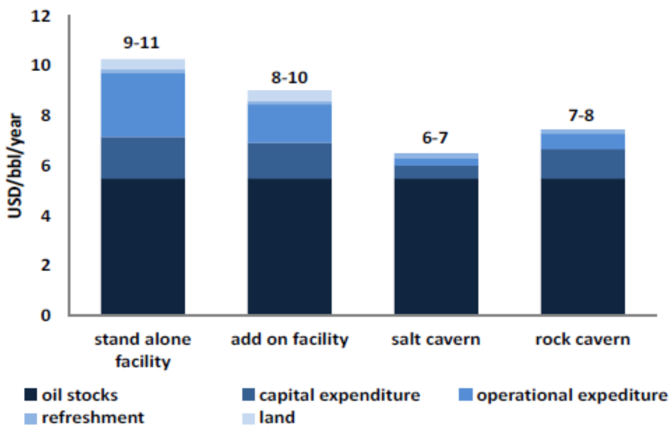
Source: Institute of Energy Economics, Japan.

Addendum: Economics of Stockpiling

Stockpiling brings numerous benefits to stockholding countries. The benefits, however, vary significantly depending on factors such as the oil intensity of GDP, the share of oil in the total energy mix, the degree of import dependence, and GDP per capita. This report does not provide economic analysis on specific countries, but introduces the recent analysis conducted by the IEA in 2013 on the *global net benefits* of stockpiling.[6] The following is a brief summary of the analysis.

The costs of representative stockpiling options are shown in Figure 2-15, based on the IEA's analysis. The range is roughly US$7–US$10/bbl, depending on the option.

Figure 2-15. Cost of Stockpiling Development



Source: IEA, Focus on Energy Security.

The benefits of stockpiling are composed of the amount of avoided GDP loss resulting from stockpiling and the reduced import bill by utilising domestic stockpiling. The IEA member countries' stockpiling system is estimated to have generated US$3.5 trillion in benefits from the past release activities. The IEA used a simulation model developed by Oak Ridge National Laboratory and calculated the expected benefits. The schematic of the simulation is shown in Figure 2-16. It assumes an unexpected supply disruption on a random basis, based on the past 30-year history of the international oil market. In the estimate, the model uses the following reference data:

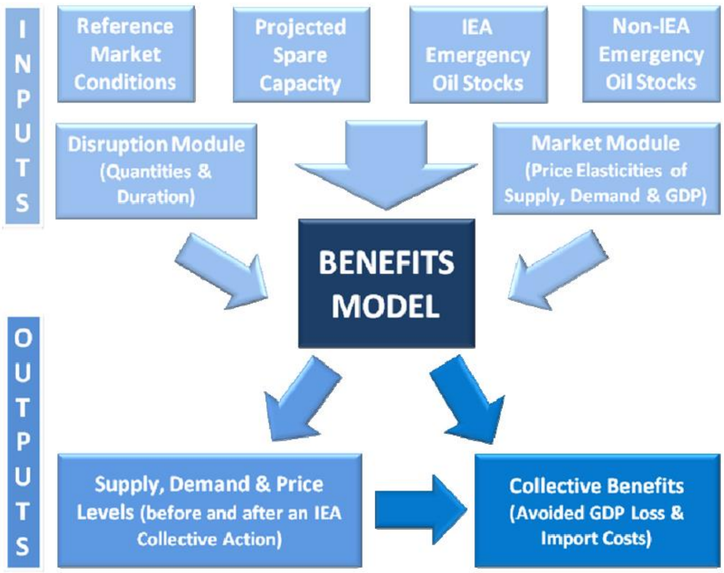
- Market conditions (demand and supply balance)
- Spare oil production capacity
- IEA emergency stock capabilities

[6] International Energy Agency, Focus on Energy Security (Paris: International Energy Agency, 2013).

- Non-IEA emergency stock capabilities
- Oil supply disruption probabilities
- Market responsiveness (price elasticity of supply and demand) and macroeconomic sensitivity to shocks (GDP elasticity toward the oil price)

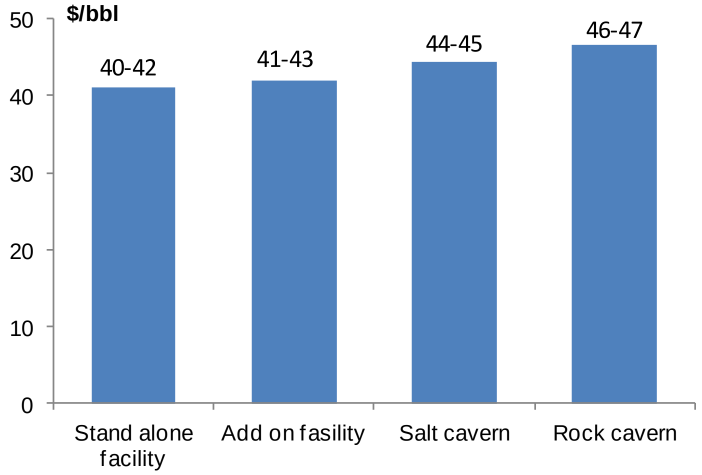
The simulation analysis estimates the global benefits of stockpiling at approximately US$3,546 billion for 30 years, equivalent to US$51/bbl. The avoided import costs amount to US$23/bbl the avoided GDP losses are US$27/bbl. Combining the cost estimates of each stockpiling type, the net benefits of stockpiling are summarised in Figure 2-17.

Figure 2-16. Cost of Stockpiling Development



Source: IEA, Focus on Energy Security.

Figure 2-16. Net Benefits of Stockpiling



Source: IEEJ based on IEA, Focus on Energy Security.

It should be noted that this is the global net benefit, and further analysis is needed to assess the net benefit for each specific country. Individual countries face additional costs that are unique to their own stockpiling development, but incremental benefits from stockpiling. However, the IEA's analysis clearly shows a significant benefit from stockpiling (US$51/bbl) and this amount is large enough to mobilise domestic resources to prompt development of stockpiling systems in ASEAN countries.