Chapter 2

Cost–Benefit Analysis on Oil Stockpiling in Indonesia, the Philippines, and Viet Nam

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Chapter 2

Cost–Benefit Analysis on Oil Stockpiling in Indonesia, the Philippines, and Viet Nam

The chapter conducts a cost–benefit analysis of oil stockpiling in Indonesia, the Philippines, and Viet Nam. Based mainly on the methodology and major assumptions of studies by the IEA and the Energy Modelling Forum of Stanford University, the analysis assumes scenarios of stockpiling options and supply disruptions. Stockpiling options are (i) national initiative, (ii) ticket stockpiling, and (iii) joint stockpiling with Middle East crude oil exporters. Supply disruption scenarios are (i) Middle East unrest, (ii) South China Sea blockage, and (iii) a natural disaster in the importing country.

1. Methodology

1.1. Country Selection

Chapter 1 looked at rising oil import dependency, oil supply risks, and stockpiling options for ASEAN countries. However, ASEAN countries vary significantly, especially in demand size, extent of import dependency, and extent of stockpiling development (Table 2.1).

Table 2.1. ASEAN Countries' Oil Stockpiling Profiles

	Oil Fundamentals			Oil Stockpiling	
	Demand in 2019 (kb/d)	Demand Increase towards 2050 (kb/d)	Import Dependency in 2019	Industry Stocks (days of demand)	Strategic Petroleum Reserves
Brunei	27	-0.2	Net exporter	31	No
Cambodia	77	N/A	100%	30	No
Indonesia	1,570	1,106	48%	14-23	No
Lao PDR	18	N/A	100%	10-21	No
Malaysia	559	15	Net exporter	30	No
Myanmar	147	279	94%	N/A	No
Philippines	402	795	97%	15-30	No
Singapore	503	73	0%	90	No

Thailand	1,147	321	66%	3.5-21.5	No
Viet Nam	448	548	47%	10-40	Yes

kb/d = thousand barrels per day, N/A = not applicable, Lao PDR = Lao People's Democratic Republic.
Source: International Energy Agency (2021b), Author.

Whilst oil supply security is important to all ASEAN countries, the study focuses on certain countries for the sake of depth and efficiency, selecting Indonesia, the Philippines, and Viet Nam, mainly for their significant demand size, growth, and import dependency. They share 50% of demand in 2019 and will account for as much as 78% of demand growth in the region towards 2050. Indonesia might most urgently need to expand oil stockpiling because of its demand size, expected growth, and low level of stocks. The Philippines' growth rate will be the highest in the region. Viet Nam' s growth will be third highest and the country is more exposed to the South China Sea than other ASEAN oil importers. Although Viet Nam has already introduced SPR, actual SPR building is behind schedule. Therefore, covering the three countries will be indicative to other ASEAN countries.

1.2. International Energy Agency Studies

As an organiser of oil emergency response of its member countries, IEA conducts studies on oil stockpiling, such as the cost–benefit analysis done in 2013 (IEA, 2013) and updated in 2018 (IEA, 2018).

The 2013 study guides countries on building or expanding oil stockpiling. The present report quantitatively assesses and compares the cost and benefit of holding oil stockpiles. The cost is calculated by adding up the cost components of a stockpiling project, estimated at US$7–US$10 per barrel. The benefit of oil stockpiling is evaluated using the estimated economic loss to the world caused by oil supply disruptions. In assessing the risk of supply disruption, the results of an analysis of the probability, and duration of disruption events, the study uses the outcome of Energy Modelling Forum (2016), a programme of Stanford University. The EMF has developed a risk assessment framework and evaluated the likelihood of oil disruptions mainly from geopolitical, military, and oil market points of view. As a result of the analysis using oil supply scenario simulations, oil stockpiles developed under the IEA framework were estimated to bring a total benefit of $3.5 trillion over 30 years (about $50 per barrel) to IEA member countries and non-IEA net oil importers. The report concludes that the net benefit of oil stockpiling is about $40 per barrel and stresses the importance of retaining and expanding oil stockpiling.

The IEA updated the study in 2018 to consider changes in the oil market, such as the growing presence of the US as an oil-producing country and volatile oil prices. Some assumptions of the cost–benefit calculation have changed, but the basic methodology remains the same. The IEA study concludes that the benefit of stockpiling outweighs the cost.

We adopt most of the methodologies of the IEA analyses in calculating the cost of oil stockpiling. However, the present study calculates the benefit for each country (Indonesia, the Philippines, and Viet Nam) separately, while the IEA analysed the benefit for the entire world.

1.3. Methodology Outline

The cost of oil stockpiling assumes a target stockpile volume and construction of new stockpile terminals to achieve a stockpiling amount of 90 days of domestic demand.[4] The construction cost of stockpiling facilities and the cost of operating and maintaining the stockpile for 30 years are accumulated and calculated to arrive at a unit cost of stockpiling (US$/barrel [159 litres] of crude oil [bbl]).

The benefit of oil stockpiling is based on how much gross domestic product (GDP) contraction can be avoided in the event of oil supply disruption. Assuming supply disruption scenarios and disruption probability exogenously, various supply situations (with or without disruptions in any given time during 30 years) are simulated randomly to calculate the benefit of oil stockpiling. Finally, the cost and benefit are compared, and if the benefit exceeds the cost, constructing additional oil stockpiles is worthwhile.

2. Cost Analysis

2.1. Main Assumptions

The cost of oil stockpiling for Indonesia, the Philippines, and Viet Nam is calculated by adding up the cost of implementing oil stockpiling projects. The target is 90 days of domestic demand, and oil storage terminals are assumed to be constructed to meet the shortfall. Oil could be stored in tanks onshore or offshore and in underground structures such as depleted oil fields or salt caverns. The study assumes that oil tanks are onshore, which is most common. The number of stockpiling days is calculated based on each country's consumption in 2019. The project life is set at 30 years, which is consistent with IEA studies on oil stockpiling.

The study consider three oil stockpiling schemes: national initiative, ticket stockpiling, and joint stockpiling with Middle East crude oil exporters. Ticket stockpiling and joint stockpiling are assumed to cover only crude oil stockpiles. For a national initiative, the ratio of crude oil and petroleum product stockpiling is set individually based on the level of oil imports and refinery capacity. Table 2.2 shows the estimated existing oil stockpiles and the assumed target stockpiles by crude oil and oil product. Indonesia is assumed to have a large crude oil stockpile because its refinery capacity is large. The Philippines and Viet Nam are assumed to have larger stockpiles of oil products than crude oil because they have fewer refineries and are expected to continue to have high dependence on petroleum product imports.

[4] The target of 90 days follows the IEA standard. However, the study sets 90 days of domestic demand instead of 90 days of net imports, which the IEA stipulates, primarily for consistency with stockpiling regulations in many ASEAN countries, where stockpiling amount is legislated in days of domestic demand or sales.

Table 2.2. Assumed Target Days of Oil Stockpiling

Indonesia

	Existing	Necessary Additions	Total
Crude oil	10 days	40 days	50 days
Oil products	10 days	30 days	40 days
Total	20 days	70 days	90 days

Philippines

	Existing	Necessary Additions	Total
Crude oil	20 days	20 days	40 days
Oil products	20 days	30 days	50 days
Total	40 days	50 days	90 days

Viet Nam

	Existing	Necessary Additions	Total
Crude oil	25 days	15 days	40 days
Oil products	25 days	25 days	50 days
Total	50 days	40 days	90 days

Source: Author.

The assumptions for the cost calculation are in Table 2.3. Most parameters are set with reference to the IEA studies. The CAPEX of a stockpiling facility consists mainly of tanks, pumps, and jetties. Tank construction for petroleum products costs more than for crude oil because product tanks, especially for gasoline, require more complex structures to lower the fire risk of low flash point. The unit cost of jetties, however, is more expensive for crude oil facilities because crude oil tankers are large.

The operating expenditure consists of initial oil purchase costs, operating expenses, land lease, and stockpile replacement costs. Since the properties of crude oil are stable, it may be replaced only once in 20 years, whilst petroleum products degrade easily and need to be replaced every 6 years. The study largely utilises IEA's assumption for most of the parameters in Table 2.3. Prices of crude oil and petroleum products are assumed at levels in the third quarter of 2021.

Table 2.3. Parameters for the Cost Calculation

Parameter		Value
General assumptions	Project life	30 years
	Interest rate	3%
Oil purchase	Crude oil Oil product	Assumed crude price at $72/bbl and product price at $79/bbl (3Q 2021 market prices)
CAPEX	Construction costs of storage facilities (excluding jetty)	$\$150/m^3$ (for crude) $\$165/m^3$ (for product)
	Construction costs of jetty	$35mn (for VLCC) $12mn (for product tankers)
OPEX	Land utilization	$3.5\ m^3/m^2$
	Land lease expenses	$\$0.3/m^2$ per month
	Operating expenses	$\$12/m^3$ per year
	Refreshment interval	Every 20 years for crude Every 6 years for product
	Cost of alternative storage during refreshment	$\$21/m^3$ per refreshment (for crude) $\$27/m^3$ per refreshment (for product)
	Terminal handling cost during refreshment	$15/mn tonne (for crude) $4/mn tonne (for product)

bbl = barrel, CAPEX = capital expenditure, m^3 = cubic metre, mn = million, OPEX = operational expenditure Q = quarter, VLCC = very large crude carrier.

Note: The interest rate could vary depending on the country's policy interest rate and the financing scheme. We follow the assumption by International Energy Agency (IEA) but, considering the interest rate is generally higher in developing countries, argue that the rate could be higher in ASEAN countries. A lower rate is available, however, for infrastructure projects such as oil stockpiling, especially if international financial assistance is secured.

Source: IEA (2013, 2018), Japan External Trade Organization (2022), Author.

National initiative stockpiling requires all the cost items. Ticket stockpiling, however, is assumed to utilise the surplus stockpiling capacity in other countries and to not bear CAPEX. In the case of joint stockpiling, the crude oil exporter is assumed to own the crude oil, and the importing country does not bear the initial oil purchase cost and stockpile replacement costs.

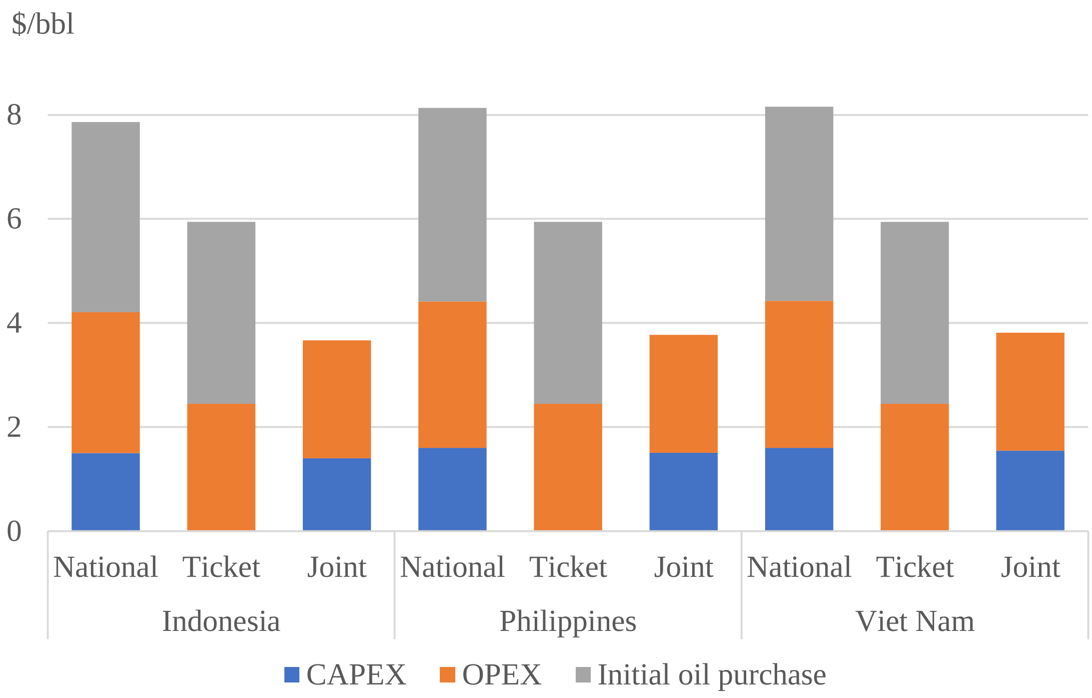
2.2. Results

The cost estimate of oil stockpiling in Indonesia, the Philippines, and Viet Nam is US$3.7–US$8.2/bbl (Figure 2.1) The difference between countries is small but the difference between stockpiling schemes is large.

For a national initiative, the largest cost component is the initial oil purchase (46% of the total), followed by operating expenditure (34%–35%) and CAPEX (19%–20%). Ticket stockpiling is assumed not to include CAPEX, and joint stockpiling does not include the initial oil purchase.[5] Therefore, the two schemes are, unsurprisingly, much cheaper than a national initiative. Whilst a national initiative costs US$7.9–US$8.2/bbl, the ticket cost is $5.9/bbl and joint stockpiling is the cheapest at US$3.7–US$3.8/bbl.

The difference in costs amongst countries is mainly due to the difference in the assumed composition of crude oil and oil products. In the Philippines and Viet Nam, which are assumed to stockpile more oil products with higher tank costs and initial inventory purchase costs, stockpile holding costs are slightly higher than in Indonesia.

Figure 2.1. Cost of Oil Stockpiling by Country and by Development Option



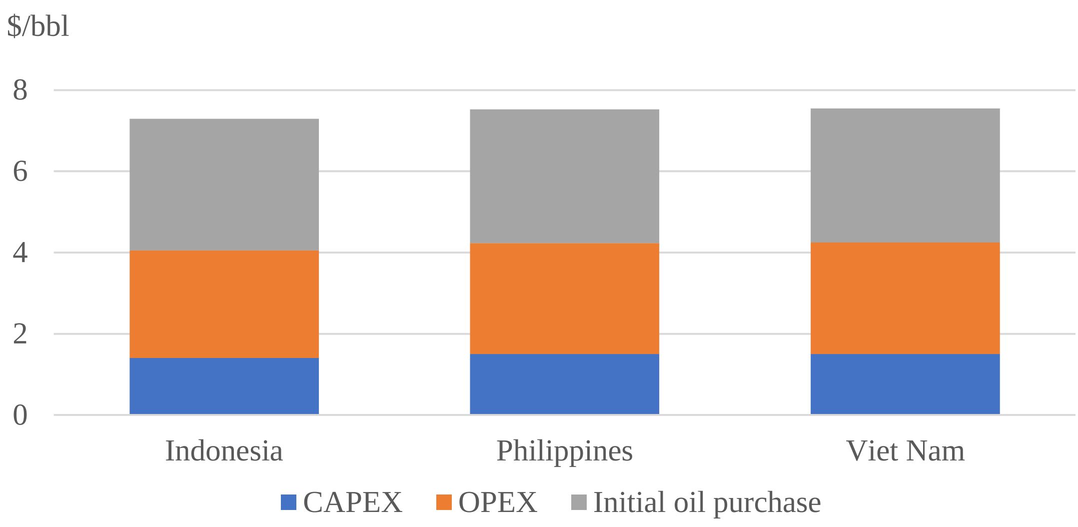
bbl = barrel, CAPEX = capital expenditure, OPEX = operational expenditure.
Source: Author.

Indonesia, the Philippines, and Viet Nam hold 20–50 days of oil stocks, all developed by national initiative without any international cooperation such as joint or ticket stockpiling. The situation is understandable because of the nature of oil supply security; a country naturally intends to retain full control of the whole stockpiling scheme within its territory. Therefore, whilst ticket stockpiling and joint stockpiling are inexpensive, assuming that the three countries solely rely on them is not realistic. Japan, for instance, has joint stockpiles with Saudi Arabia, United Arab Emirates, and Kuwait, and had 7 days of joint stockpiles out of 246 days of overall stockpiles at the end of 2020. The study assumes that Indonesia, the Philippines, and Viet Nam will develop their stockpiling mainly by national initiative and that

[5] The actual ticket fee and other cost sharing depend on a bilateral contract between capacity provider and user.

joint and ticket stockpiling will be supplemental. The target 90 days would be broken down as 75 days by national initiative, 5 days by ticket stockpiling, and 10 days by joint stockpiling, and the unit cost of stockpiling would be US$7.3–US$7.6/bbl (Figure 2.2).

Figure 2.2. Average Cost of Oil Stockpiling by Country



bbl = barrel, CAPEX = capital expenditure, OPEX = operational expenditure.
Source: Author.

Since a pure national initiative costs US$7.9–US$8.2/bbl, joint and ticket stockpiling clearly reduce some cost. Indeed, if the three countries developed 90 days of stockpiling based on the above combination of stockpiling options, they could save as much as US$0.4–US$1.6 billion from a pure national initiative. Joint stockpiling with Middle East crude oil exporters could offer not only economic value but also strategic value since the Middle East would be the main source of additional crude oil supply.

3. Benefit Analysis

3.1. Main Assumptions

The benefits of oil stockpiling are assessed by the avoided contraction in real GDP caused by a disruption in oil supply. We, therefore, compare the case of having no additional oil stockpiling with the case of having 90-day stockpiling.

The calculation method is as follows. First, oil supply disruption scenarios, occurrence probability, and the amount of oil disrupted are set exogenously. Next, under the probability, we simulate 1,000 cases over 30 years using the Monte Carlo method, utilising random numbers. The loss of real GDP in the event of supply disruption is calculated separately, and the cumulative GDP loss for 30 years is calculated. This loss is converted to an annual basis and further divided by the 90-day oil stockpiles to obtain the benefit of oil stockpiling per barrel.

The following three scenarios are assumed as oil supply disruptions: (i) a Middle East emergency, (ii) a blockade of the South China Sea, and (iii) a natural disaster in the importing country. Assumptions on the impact of each disruption event on each country and its probability of occurrence are shown in Table 2.4. The probability of occurrence of each disruption event is based on Energy Modelling Forum (2016), which estimates the annual probability and volume of oil supply disruptions that may occur in places such as the Middle East, Africa, and the Russian Federation. The Energy Modelling Forum estimated probability ranges from 1.03% to 6.38% per annum, depending on the scenarios. For simplicity, we average the percentages and use 4.0% per annum as occurrence probability. The duration of the disruption is assumed to be 90 days.

Table 2.4. Assumptions on the Impact of Oil Disruption and its Probability

	Indonesia	Philippines	Viet Nam	Occurance Probability per Annum
Middle East crisis	259 kb/d (10% of oil import)	110 kb/d (7% of oil import)	102 kb/d (6% of oil import)	4.0%
South China Sea blockade	0 kb/d	0 kb/d	203 kb/d (11% of oil import)	
Domestic natural disaster/incident	157 kb/d (6% of oil import)	40 kb/d (2% of oil import)	45 kb/d (3% of oil import)	

kb/d = thousand barrels per day.
Source: Energy Modelling Forum (2016), Author.

The impact of oil supply disruptions on real GDP consists of the contraction of economic activity due to the loss of oil as raw material or fuel and the higher cost of oil imports. The contraction of economic output due to a disruption occurs when oil is unavailable in industrial sectors that use oil as raw material or fuel. A decline in output in one sector caused by oil shortages will cause a decline in output in other sectors that use that output as an intermediate input. Due to the spillover effect, an oil shortage will have a significant impact on a country's total economic output. The impact can be estimated by applying the Ghosh model using the input–output table. The model is developed to calculate changes in gross sector outputs for exogenously specified changes in sector inputs. We use the input–output table constructed by Asian Development Bank (2022) and calculate the rate of change in total output if oil imports were disrupted at the rates shown in Table 2.4. The main assumptions used in the calculation are summarised in Table 2.5.

Table 2.5. Parameters for the Benefit Calculation

Parameter	Value	Remark
Project life	30 years	
Crude price in 2021	$72/bbl	Same as the cost calculation
Crude price in 2050	$88/bbl	
Product price in 2021	$79/bbl	Same as the cost calculation
Product price in 2050	$97/bbl	
GDP growth in Indonesia	4.6%	
GDP growth in Philippines	4.2%	
GDP growth in Viet Nam	5.4%	

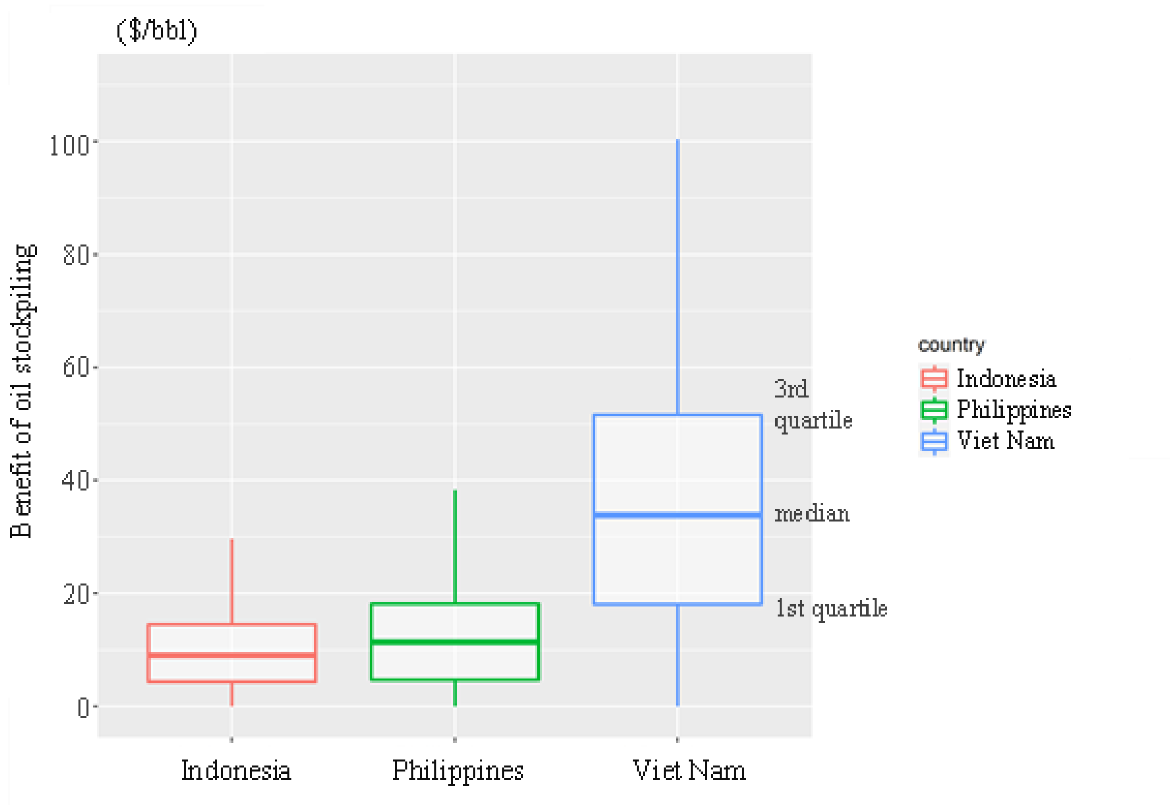
bbl = barrel, GDP = gross domestic product.
Source: International Energy Agency (IEA) (2018), IEA (2021), Author.

3.2. Results

The benefits of oil stockpiling vary, depending on no supply disruption (zero benefits) and supply disruption scenarios. Figure 2.3 shows a box plot of the benefits of oil stockpiling for each country under 1,000 simulations. The upper and lower limits (i.e. $39 and $0 in the case of Indonesia) represent the highest and the lowest benefit. Excluding the top 250 and bottom 250 values generates the range of the first and third quartiles, which can be considered statistically meaningful. The median is the 500th value from the highest (or the lowest). The first quartile is the 250th value from the lowest, and the third quartile is the 250th value from the highest. The benefits range from US$4.4/bbl–US$14.5/bbl for Indonesia, US$4.7/bbl–US$18.2/bbl for the Philippines, and US$18.3/bbl–US$52.5/bbl for Viet Nam (ranges from the first and third quartiles). The median values are US$9.1/bbl for Indonesia, US$11.4/bbl for the Philippines, and US$34.4/bbl for Viet Nam.

The reason oil stockpiling in Viet Nam is estimated to have particularly high benefit stems from the country's location and its large exposure to the South China Sea. A blockade in the South China Sea would have a catastrophic impact on oil supply to Viet Nam, but less so on oil supply to Indonesia and the Philippines. Indonesia's dependence on oil for its primary economic sectors, such as manufacturing and construction, is lower than the Philippines' and Viet Nam's. Therefore, the benefits of oil stockpiling in Indonesia and the Philippines are smaller than in Viet Nam.

Figure 2.3. Estimated Benefit of Oil Stockpiling

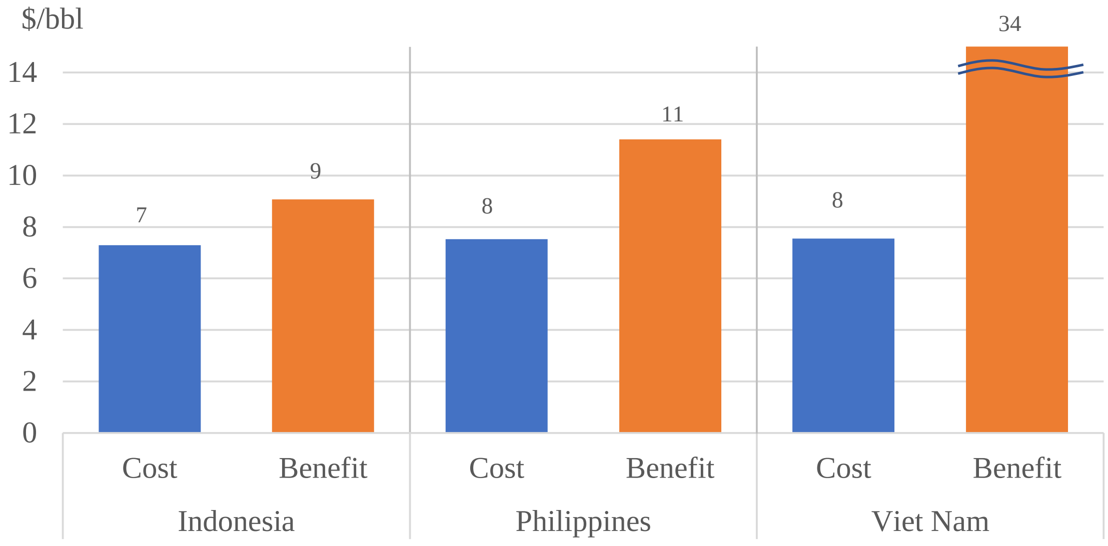


bbl = barrel.
Source: Author.

4. Summary and Implications

Comparing the costs and benefits (i.e. median values of Figure 2.4) of oil stockpiling in Indonesia, the Philippines, and Viet Nam, the expected benefits of oil stockpiling exceed the costs in all countries. The benefit is extremely large in Viet Nam, which is highly exposed to the risk of a blockade of the South China Sea. The evaluations so far assume a 90-day oil stockpile in accordance with IEA standards. The three countries already have oil reserves of about 20–50 days' worth of oil and building them up further would provide more benefit.

Figure 2.4. Summary of the Cost and Benefit Analysis



bbl = barrel.
Source: Author.