OPTIMIZING DELIVERY OF NATIONAL OIL CONSUMPTION IN INDONESIA: A CASE FOR PERTAMINA AS NATIONAL OIL COMPANY

Sutanto SOEHODHO
Center for Transport Studies
Department of Civil Engineering
University of Indonesia
Depok 16424, Indonesia
Fax. 62-21-7270028
E-mail:tanto@eng.ui.ac.id

Abstract: In Indonesia the trend of domestic oil fuel demand has been traditionally increasing, and so is the complexity of supply distribution due to the scope of area served. This paper deals with the development of optimization model of distribution strategies to achieve minimum transport cost. The proposed optimization model would cover the sea oil physical distribution system from supply point (e.g., refinery) to demand at depot, through evaluation on storage capacity, jetty capacity, geographical distance and condition, and dummy location (e.g., floating storage location for import oil fuel). The Model is implicated to the case of country wide oil distribution in the country through which it relies mostly on sea transport. Results have shown that some changes in delivery strategies in routing and transshipment would gain significant cost savings.

1. INTRODUCTION

In line with the macro-economic growth of Indonesia the trend of domestic oil fuel demand is increasing. This situation may have no much difference even in the era of economic crisis happening since 1998. Domestic oil consumption currently has reached 50 million-tons with average growth of 5% per year. To comply with the domestic demand oil is fulfilled from 9 local refinery units and some are imported. To distribute the oil consumption throughout the country most seafed depots are playing more roles as compared to the inland depots, and they are delivered through either the transshipment or back-loading terminals.

Looking at the geographical condition of the country as archipelagoes it is inevitable that tanker fleet or sea transport would still take an important role in distribution. As an illustration currently this sea transport occupies at least 70% of total oil distribution at national scale. The total cargo carried by the tanker fleet in 1998/1999 reached 87 million-tons and assigning 175 tankers. While in the year of 1999/2000 this figure declined down to 72 million-tons due to the economic crisis, and assigning a fleet of 167 tankers with total average of 4 million DWT.

Based on the geographic condition and potential demand it is clear that the transportation cost would be a significant variable to be considered for setting up the selling price of the oil fuel consumption besides its crude oil price and other production cost counterparts. So to cope with future needs of better delivery the existing model distribution that kept priority on oil availability with specified quality at certain instant known as '*security of supply*' is no longer economic to be sustained. This study aims at developing strategic model of oil distribution throughout the country that could comply with demand and certain level of service minimizing the total distribution costs.

As case to comprehend performance of the proposed strategic distribution data from one major suppliers of the national oil demand (e.g., PERTAMINA Oil Company) and its related distribution strategy is evaluated and contrived as a base for proposed strategy implementation.

2. PROBLEM IDENTIFICATION

Problems faced by the oil fuel distribution in Indonesia are apparently complex due to its coverage area and other technical problem like;

- Relatively far distance between the refineries and depots
- Required additional import oil due to limitation of the local refineries' production
- Capacity limitation of the stock tanks
- Limitation on the access of the sea transport
- Capacity limitation of the ports of entry
- Limitation of suitable delivery fleet to each port of entry
- Increasing tendency of oil fuel consumption
- Etc.

The unbalanced situation of supply and demand along with operational problems mentioned it is no more realistic to maintain the 'security supply' concept. Moreover, it is learnt that most of the fleet is misused as floating storage, transit terminal, emergency terminal and connecting pipes.

This is the aim of this research to improve such deteriorating distribution pattern of high cost economy with better distribution strategies and best utilization of the available fleet and infrastructures. Furthermore, the followings scope and assumptions are adopted;

- Oil fuel consumption is limited to three types of premium, kerosene and diesel that all together amount to almost 80% of total domestic consumption
- Daily consumption per depot (daily of take) is assumed constant over the year
- Distribution supply pattern is a single port and each depot is served by one type of fleet
- Routes to be analyzed cover 69 sea depots, 4 transit terminals, and 7 back lading terminals throughout the country
- Tanker fleets used range from medium (30,000DWT), general purpose II (17,501-25,000 DWT), general purpose I (6,501-17,500 DWT), small II (3,501-6,500 DWT), small I (1,501-3,500 DWT) to bulk lighter (less than 1,500 DWT).
- Analysis is performed within the context of 5 ensuing year of demand supplied only by PERTAMINA
- Refinery production is fixed over the year

Based on the identified problems it is then necessary to set up some variables included in the proposed model. These variables are preemptively determined as followings;

- Demand for oil fuel in each area of the country

- Available stock capacity
- Production capacity of the refinery
- Quantity of imported oil fuel
- Distance between refinery and depot
- Port capacity

These variables are to be materialized in the logistic/distribution model developed as mathematical programming that includes transshipment. The proposed model is analyzed by the combination of statistical approach for demand prediction, visual graphical scratch for determining desired routes and linear programming model to solve the general mathematical programming. Solving the model would require a heuristic approach of the combination to reach at subsequently improvement of the objective function (i.e., minimized transport cost or total distribution cost including the infrastructure investment).

In the ensuing sections, the determination of variables and their parameters are discussed, and this discussion is followed with the formulation of the expected model. Some approaches on the analyses are in subsequent discussion to reach some local optimized values of the objective functions. In last section some concluding remarks are drawn to impose potential improvement proposed by the model.

3. SUPPLY-DEMAND PERSPECTIVES FOR OIL FUEL

As already mentioned before that it is apparent that the national demand for oil fuel would be growing in the years to come with average growth of 5% per year. Current demand of oil fuel has been identified to reach 50 million-tons per year through which most of the supply is accomplished by sea-transport (70% of total demand). So by considering the geographical condition of the country it is certain that maintaining the supply would rely on sea distribution performance currently by tankers. Sea-transport mode of oil distribution in the country includes several facilities like tankers, sea-fed, transshipment terminals, back-loading terminals, floating terminals, pipes, and others to reach demand points with ports or inland infrastructures.

On supply side, the scope discussed in this research covers sea supply mode of 69 units of sea-depots, 6 transit terminals and 5 installations serving distribution of oil coming from both domestic and imported products. The domestic products are exploited from 8 refineries from which 4 out of those served by tanker fleet, Dumai, Plaju, Cilacap and Balikpapan, while the rest are distributing oil to the demands in the peripheries, namely Pangkalan Brandan, Kasim, Cepu and Balongan. So what are being discussed in this case would comprise only 4 refineries. Oil supplies both from domestic and imported products are supplied to customers through depots. These depots may have two types of depots of sea-fed depots served by tankers and barges, and the inland depots served by pipes, railway tankers, and car tankers.

Clustering the distribution system the 69 depots are organized under 8 local logistics and marketing units called as UP's dispersed throughout the country, namely UP1 in North Sumatera/Medan City, UP2 in South Sumatera/Palembang City, UP3 in Jakarta City, UP4 in Semarang City, UP5 in Surabaya City, UP6 in Kalimanatan/Balikpapan City, UP7 in Ujung Pandang City and UP8 in Jayapura City. Furthermore. Figure 1 illustrates the sea oil distribution network in the country. In the fiscal year of 1999/2000 these UP's had total production of 42,197,967 kilo-liters as can be summarized in Table1.

Table 1. Production Plan of Refineries in 1999/2000 (kilo-liters)

UP	Avigas	Avtur	Premium	Kerosene	Gasoline	IDO	Fuel Oil	Total
UP1	0	0	0	67,093	35,613	0	15,740	118,446
UP2	0	536,423	1,009,887	1,298,608	4,696,008	0	0	7,540,927
UP3	5,565	108,747	1,145,027	855,193	1,281,120	140,068	341,028	3,876,746
UP4	0	113,835	2,984,669	3,553,207	4,191,859	180,451	3,593,908	14,617,928
UP5	0	491,748	2,605,484	2,639,984	4,797,919	135,616	0	10,670,751
UP6	0	0	3,062,572	507,646	1,238,829	134,980	0	4,944,028
UP7	0	0	39,906	71,226	58,507	0	173,932	343,572
UP8	0	0	0	21,304	46,265	0	0	67,570
Total	5,565	1,250753	10,847,554	9,014,262	16,346,120	591,115	4,124,608	42,179,967

Source: PERTAMINA Oil Company

As could be predicted in 1999/2000 there were demand for oil fuel as summarized in Table 2. And since there were no sufficient supplies from local domestic products imported oils were not inevitable, and figures of such lack of supplies are summarized in Table 3.

Table 2. Demand of Oil Fuel in 1999/2000 (kilo-liters)

UP	Avigas	Avtur	Premium	Kerosene	Gasoline	IDO	Fuel Oil	Total
UP1	277	101,569	1,348,165	1,227,071	3,325,586	56,261	634,062	6,692,991
UP2	35	17,441	715,183	626,797	1,906,250	76,823	341,144	3,684,673
UP3	1,020	603,333	3,973,587	3,626,422	4,975,423	770,130	2,802,908	16,652,823
UP4	302	32,177	1,240,843	1,155,170	2,295,863	88,668	806,332	5,619,355
UP5	996	406,239	2,319,538	2,247,836	2,811,780	223,127	817,265	8,826,781
UP6	2,081	66,767	599,739	578,599	2,595,022	66,759	168,891	4,077,858
UP7	32	92,509	678.979	506,285	1,087,804	117,817	84,836	2,568,262
UP8	1,136	45,852	168,471	197,501	877,216	13,695	11,789	1,315,660
Total	5,879	1,366,887	11,044,505	10,065,681	19,874,944	1,413,280	5,667,227	49,438,403

Source: PERTAMINA Oil Company

Table 3. Imported Fuel Oil for Domestic Consumption in 1999/2000 (kilo-liters)

Product	Supply	Demand	Difference (Import)
Avigas	5,565	5,879	314
Avtur	1,250,753	1,366,887	116,134
Premium	10,847,544	11,044,505	196,961
Kerosene	9,014,262	10,065,681	1,051,419
Gasoline	16,346,120	19,874,944	3,628,824
IDO	591,115	1,413,280	822,165
Fuel Oil	4,124,608	5,667,227	1,542,619
Total	42,179,967	49,438,403	7,258,436

Source: PERTAMINA Oil Company

Furthermore, due to limited capacity of stock tanks to accommodate imported oils PERTAMINA had to rent two permanent floating storages (e.g., tankers of VLCC type with 300,000 DWT) at Teluk Semangka and Kalbut in East Java. From such storages, oils were transshipped by smaller fleet (e.g., tankers of MR type with 30,000 DWT or GP type with 17,500 DWT) through depots or transit terminals/back loading terminals. So in this research for balance of supply and demand the imported oil fuel is settled at Teluk Semangka and Kalbut as dummy supply points in the network (see Figure 1).

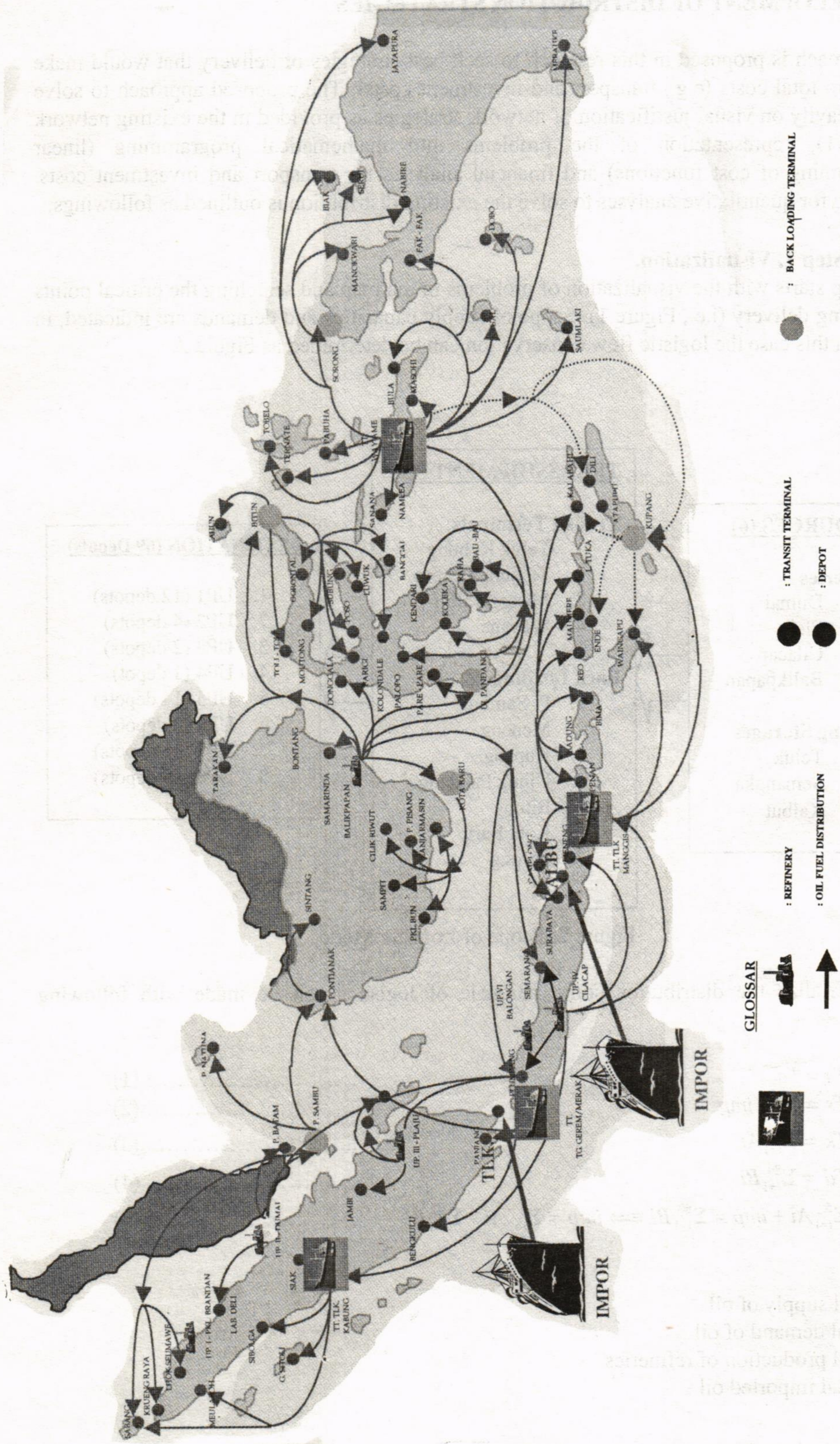

Figure 1. Illustration of Existing Oil Fuel Sea-Transport Distribution in Indonesia

4. DEVELOPMENT OF DISTRIBUTION STRATEGIES

An approach is proposed in this research to seek best strategies of delivery that would make minimum total costs (e.g., transport and investment costs). The proposed approach to solve relies heavily on visual justification of network strategies as provided in the existing network Figure 1), representation of the problems into mathematical programming (linear programming of cost functions) and financial analyses for transport and investment costs. Stepping for quantitative analyses to solve the existing distribution is outlined as followings;

- **Step 1. Visualization.**

This step starts with the visualization of problems in the map and searching the critical points of existing delivery (i.e., Figure 1). Scope of supply capacities and demands are indicated, in which in this case the logistic flow conservation can be determined as Figure 2.

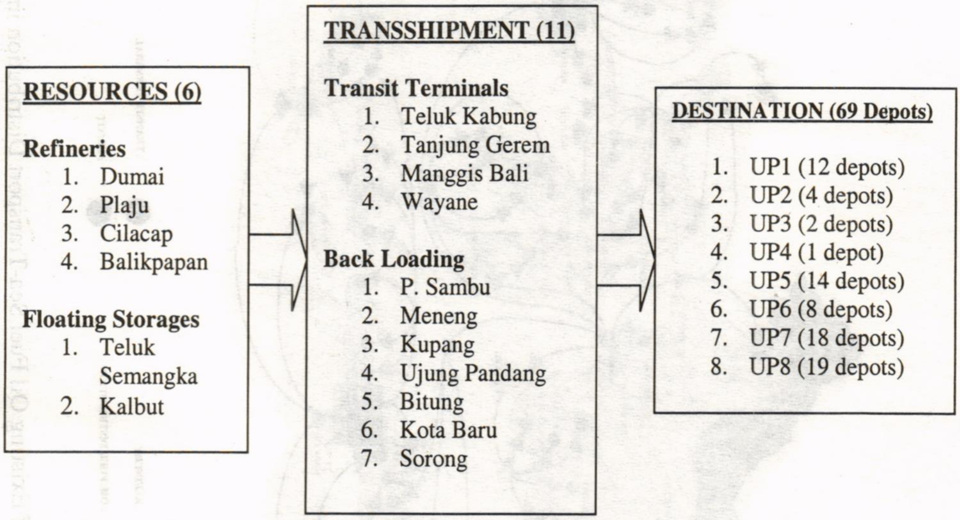

Figure 2. Scope of Logistic Mode

To materialize the distribution some rationale of logistics can be made with following models;

$$Ts = Td \quad \text{.............................. (1)}$$

$$Ts = Tk + imp \quad \text{.............................. (2)}$$

$$Tk = \Sigma_{i=1}^{5} Ai \quad \text{.............................. (3)}$$

$$Td = \Sigma_{i=1}^{80} Bi \quad \text{.............................. (4)}$$

$$\Sigma_{i=1}^{5} Ai + imp = \Sigma_{i=1}^{80} Bi \equiv\Rightarrow imp = \Sigma_{i=1}^{5} Ai - \Sigma_{i=1}^{80} Bi \quad \text{.............................. (5)}$$

where;
Ts = total supply of oil
Td = total demand of oil
Tk = total production of refineries
imp = total imported oil

Ai = production of refinery i after deducted by local demand
Bi = demand at each depot i

Transshipment nodes are then supplied with amount as much as buffer plus demand at the nodes, or in other words;

$$Si = Buf = \Sigma_{i=1}^{5} Ai + \Sigma_{i=1}^{80} Bi \qquad \text{.........................} (6)$$

$$Di = Di + \Sigma_{i=1}^{5} Ai = \Sigma_{i=1}^{80} Bi \qquad \text{.........................} (7)$$

where;
Di = original demand at transshipment node i
Buf = buffer at transshipment node
Si = supply at transshipment node i

- **Step 2. Mathematical Representation.**

This step would describe the problem of distribution into mathematical programming model of transport costs. As can be found in Mulyono (2000) some of the operating costs and specifications of sea service as well as various facility capacities are clearly derived. Minimum cost function is set up for the case as followings;

$$Min_{c,x} Z(C,X) = \Sigma_{ij} C_{ij} X_{ij} \qquad \text{....................} (8)$$

subject to

$$\Sigma_j X_{ij} \le a_i \forall i,j \qquad \text{....................} (9)$$

$$\Sigma_i X_{ij} \ge b_j \forall i,j \qquad \text{..................} (10)$$

In this particular case of PERTAMINA i= 18 and j = 80. Furthermore, to materialize the mathematical programming a transportation matrix is set up as following;

	D_1	D_2	D_3		A
S_1	C_{11} X_{11}				a_1
S_2					
B	b_1	b_2	b_3		

where;
Di = depot i
Bi = demand at depot i
Si = refinery i
Ai = supply at from refinery i
C_{ij} = transport cost from Si to Dj
X_{ij} = total quantity of oil from Si to Dj

To comply with the matrix existing supply and demand in 1999/2000 and their splits are summarized in Table 4 and Table 5 respectively.

Table 4. Mode Split of Oil Supply in 1999/2000 (kilo-liters)

Refinery Unit	Supply Mode		Total Production
	Land	Sea	
UP1 – Brandan	102,706	-	102,706
UP2 – Dumai	1,353,202	5,651,301	7,004,503
UP3 – Plaju	1,077,889	2,203,451	3,281,340
UP4 – Cilacap	4,819,657	5,910,078	10,729,735
UP5 - Balikpapan	998,733	9,044,654	10,043,387
UP6 – Balongan	4,809,047	-	4,809,047
UP7 – Sorong	169,639	-	169,639
UP8 – Cepu	67,569	-	67,569
Teluk Semangka	-	3,105,183	3,105,183
Kalbut	-	1,672,021	1,672,021
Total	13,398,442	27,586,688	40,985,130

Source: PERTAMINA Oil Company

Table 5. Mode Split of Oil Demand in 1999/2000 (kilo-liters)

Distribution Unit	Supply Mode		Total Demand
	Land	Sea	
UP1 – Medan	1,450,538	4,450,284	5,900,822
UP2 – Palembang	1.077,889	2,170,341	3,248,230
UP3 – Jakarta	7,343,530	5,131,902	12,475,432
UP4 – Semarang	2,363,819	2,328,057	4,691,876
UP5 – Surabaya	-	7,379,154	7,379,154
UP6 – Balikpapan	993,027	2,780,333	3,773,360
UP7 – Ujung Pandang	-	2,273,068	2,273,068
UP8 - Jayapura	169,639	1,073,549	1,243,188
Total	13,398,442	27,586,688	40,985,130

Source: PERTAMINA Oil Company

- **Step 3. Financial Analyses.**

This step aims at developing of some financial analyses on economic viability of the distribution strategies. The analyses are not limited to the transport cost merely but also, in some extent, to the investment costs of supporting facilities to distribution models. Assessment to the tanker fleet, stock tanks, and terminals are critically important to derive the real cost of investment and possible rate of return for the investment itself. As last step of analyses this step may produce iterations to the prior steps for optimal solution, and the process could continue up to a certain level of local optimality agreed.

To come up with some numerical analyses various values of variables are to be determined first, Muyono (2000) made details of quantification of such variables based on real data. Fleet is of prime concern in deriving sound strategies provided quantity of demands and supplies in place along with some supporting distribution facilities. Based on the current fleet Mulyono summarized the properties as shown in Table 6. Utilization of each type of fleet is further decided based on certain function of;

$$FleetType = f[Kt, Kd, Ka] \quad \text{.......................... (11)}$$

where *Kt, Kd, Ka* respectively denote minimum stock tank capacity (e.g., 1.286 X ship *ECC* X 90% X DWT), minimum berth capacity (e.g., ship type DWT), and minimum draft (e.g., ship draft + clearance). While *ECC* is equal to [90 % X ship DWT], and safety stock is always 30% higher than the stock tank capacity.

Table 6. Fleet Operational Properties

	TYPE OF CARRIER FLEET					
	Bulk Lighter (BL)	Small 1 (SM1)	Small 2 (SM2)	General Purpose 1 (GP1)	General Purpose 2 (GP2)	Medium Range (MR)
No. of Fleet	5	27	19	8	9	16
Voyages/6 months	159	847	474	182	163	256
Miles Cruised (miles)	67,220	483,870	483,870	304,479	149,051	238,999
Quantity (KL's)	241,637	2,376,834	2,581,087	2,053,565	2,928,196	8,720,697
Average Cost/KL/Mile (US$)	0.02709	0.01101	0.01019	0.00877	0.00429	0.01146
Kt (KL)	0 – 2,256	2,257- 3,500	5,267 – 9,980	9,981 – 26,330	26,331 – 45,140	45,140
Kd (DWT)	0 – 1,500	1,501 – 3,500	3,501 – 6,500	6,501 – 17,500	17,501 – 25,000	25,000
Ka (meters)	0 - 5	5 -6	6 - 7	7 - 9	9 - 11	>11

5. RESULTS OF ANALYSES

Iterations of steps proposed above were done to seek the best strategies of delivery or distribution as compared to the existing distribution scheme. What lies as an existing scheme PERTAMINA still relies on tramper system with assumption that growth of demand would be proportionally equal for each depot. This system was predicted to have total transport cost of US$ 186,707,742 (e.g., of 35,430,637 KL oil carried at transport cost of 5.2695 US$/KL), and if this figure should be added with the cost for floating storage of US$ 13,043,954 total amount of cost per year becomes US$ 199,751,696. Since this system is still considered high cost, some scenarios of deliveries are then analyzed (i.e., with the help of *Quantitative Systems for Business / QSB* software @) as followings.

- **Scenario 1.**

This scenario can be interpreted as an effort to make best use of existing facilities, with some changes of which some depots are to be supplied from different refineries with floating storage located in Teluk Semangka and Kalbut – Situbondo. Optimization on quantity carried in this scenario has resulted in change from 27,586,688 KL to 35,430,637 KL with total transport cost of US$164,774,520. Although, there is secondary transportation for the distribution due to increase in quantity (e.g., 35,430,637 – 27, 586,688 = 7,843,949 KL) cost savings can be achieved. Furthermore, Table 7 summarizes the quantity split among carriers, and its distribution network is shown Figure 1.

Table 7. Split of Oil Fuel Quantity Carried by Different Fleet

Fleet Type	Quantity Carried (KL)	Transport Cost (US$)
Bulk Lighter	1,456,905	17,281,790
Small I	961,947	8,407,825
Small II	7,563,115	30,789,731
General Purpose I	1,564,162	7,273,818
General Purpose II	5,659,608	31,095,966
Medium Range	18,224,900	69,925,391
Total	35,430,637	164,774,520

- **Scenario 2.**

In this scenario better improvement is made by minimizing the secondary transportation of distribution, and kept maintaining the availability of the floating storage at same place. The improvement has reached total quantity carried up to 32,262,257 KL, in which the secondary transportation is reduced down to 4,675,569 KL, and results in transport cost of US$ 152,671,480. This scenario, however, requires some small amount of investment for stock tanks (e.g., US$ 11,000,000). Furthermore, quantity split carried by each fleet is summarized in Table 8, and the related supply distribution is shown in Figure 3.

Table 8. Split of Oil Fuel Quantity Carried by Different Fleet

Fleet Type	Quantity Carried (KL)	Transport Cost (US$)
Bulk Lighter	1,456,905	16,467,170
Small I	961,947	8,212,908
Small II	6,239,515	27,079,194
General Purpose I	1,903,662	9,692,896
General Purpose II	4,946,728	27,797,679
Medium Range	16,753,500	62,772,785
Total	32,262,257	152,671,480

- **Scenario 3.**

This scenario attempts to make the distribution better off by changing the roles of floating storage at Teluk Semangka and Kalbut. This floating storage is suggested to be eliminated, and replaced with establishment of transit terminals in Tanjung Gerem and Manggis (see Figure 4. With this change total quantity carried becomes 29,151,200 KL with secondary transportation quantity of only 1,564,512 KL, and results in reduced transport cost of US$ 152,358,320.

In this scenario there is some consequent costs of investment for the two transit terminals through which should be considered for their feasibility. Mulyono (2000) assessed the feasible costs for such investment would amount up to US$ 164,000,000 including additional transport costs of about US$11,000,000. This proposal looks attractive since the existing floating storage (e.g., Teluk Semangka and Kalbut) mostly use very old tanker ships of 1970's (e.g., VLCC type) in which their maintenance and up-grade costs are apparently quite expensive. Further financial analysis is then tempted to compare the floating storage existence and its elimination by replacing the two transit terminals (e.g., Tanjung Gerem and Manggis). This comparison can be made by evaluating difference of transport costs with and without floating storage and transit terminal investment cost with the its floating storage rent and maintenance. Based on 7% annual interest rate for 20 years depreciation (A/P, 7%, 20) save transport cost per year without floating storage would be US$ 313,160, and the annual cost for investment would be US$ 14,443,200. So considering the two costs it would become justified and more attractive to replace the floating storage with transit terminals when rent cost for the floating terminals is higher than US$ 14,130,040 per year (e.g., US$ 14,443,200 – 313,160).

In summary Table 9 provides comparisons among the scenarios and existing condition (tramper system).

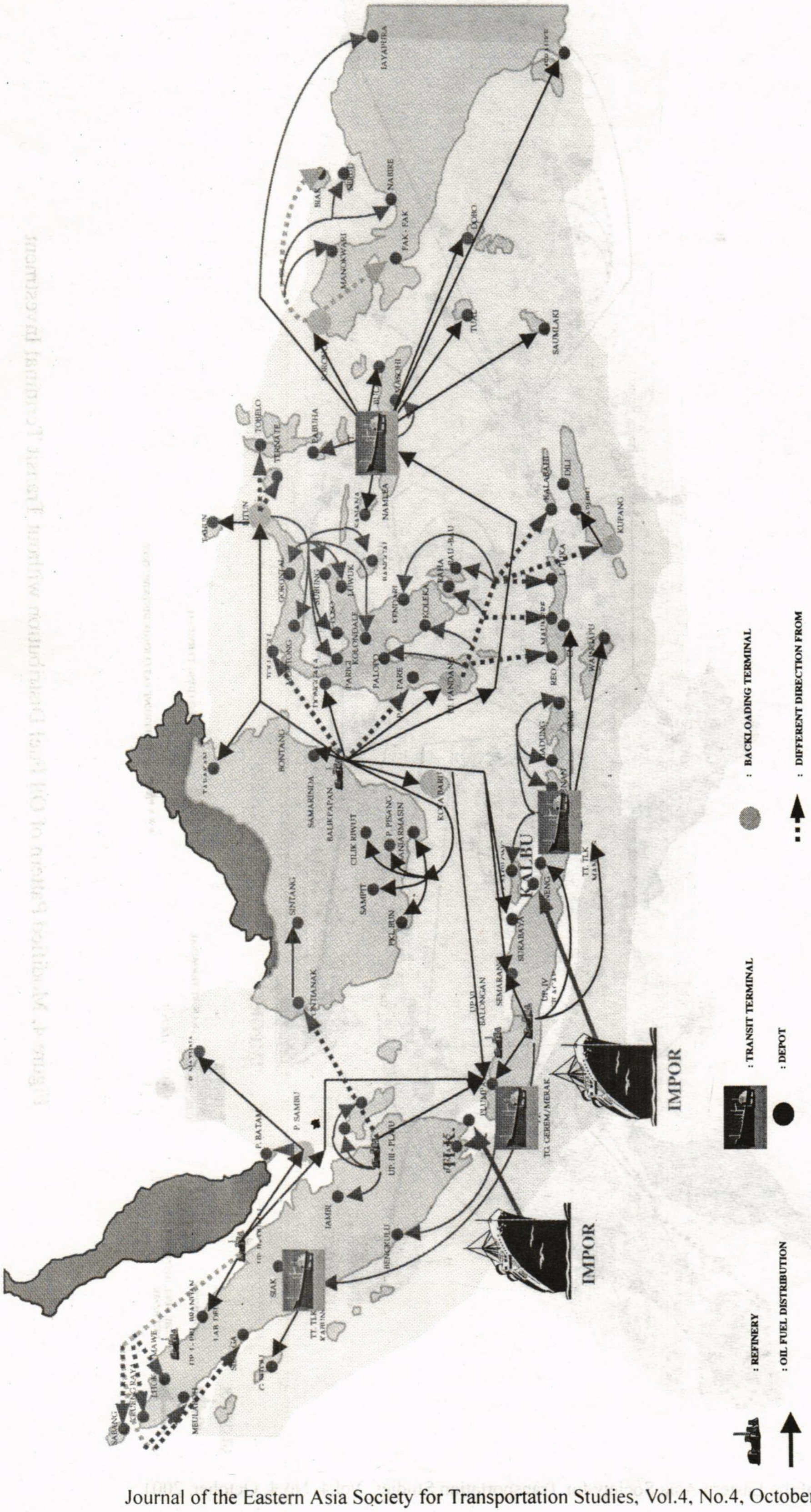

Figure 3. Modified Pattern of Oil Fuel Distribution without Investment

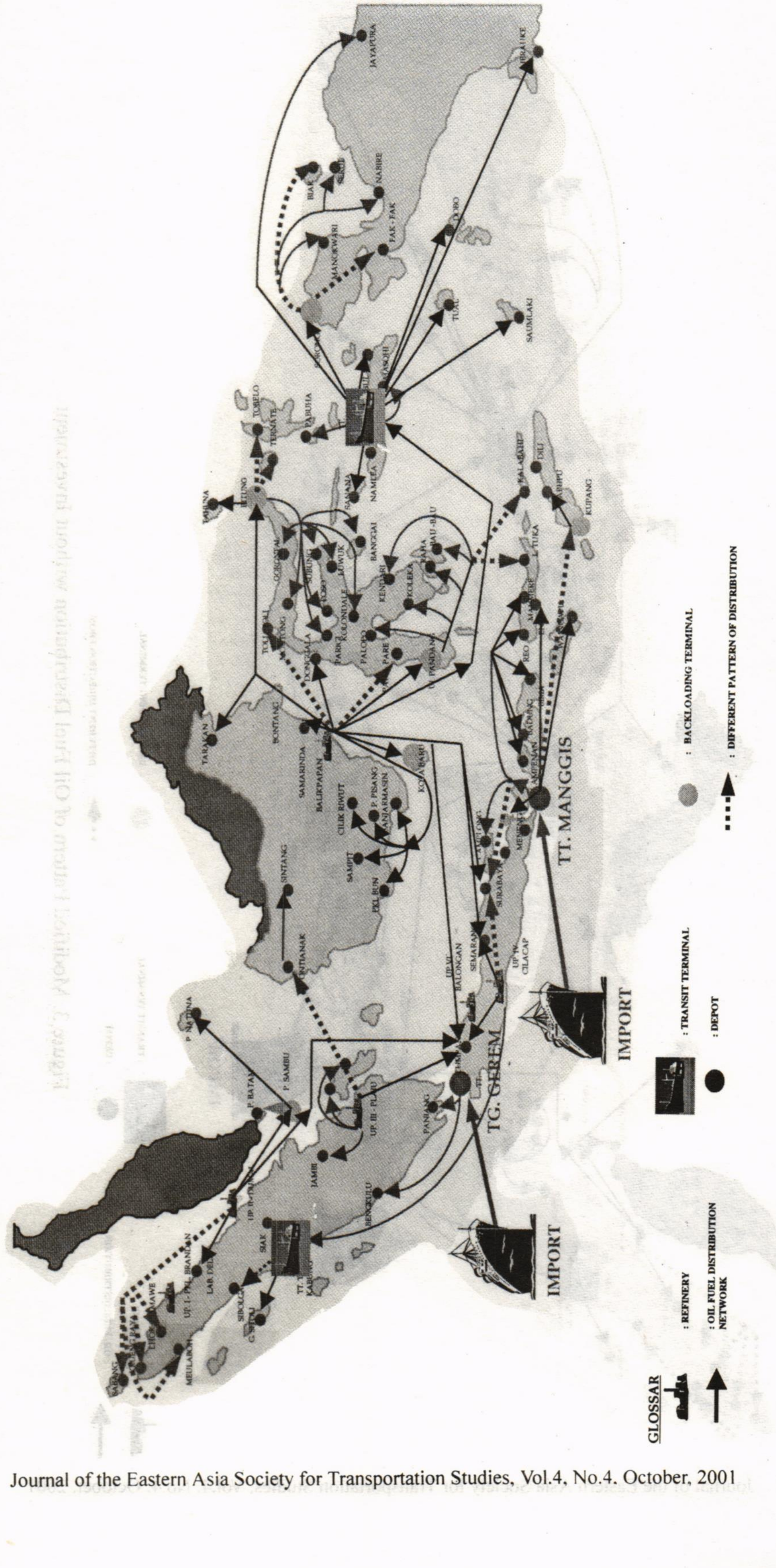

Figure 4. Modified Pattern of Oil Fuel Distribution without Transit Terminal Investment

Table 9. Cost Structures for Different Scenarios of Distribution

Cost Structure	SCENARIO			
	Tramper System (Existing)	Reschedule (Modified Existing) or Scenario 1	Additional Stock Tanks or Scenario 2	New Transit Terminals or Scenario 3
Investment Cost (US$)		-	11,000,000	164,000,000
Transport Cost (US$/year)	186,707,742	164,774,520	152,671,480	152,358,320
Floating Storage Cost (US$/year)	13,043,954	13,043,954	13,043,954	0
Return on Investment (US$/year)	0	0	1,038,400	15,481,600
Total Transport Cost (US/year)	199,751,696	177,818,474	166,753,853	167,839,920
Saved Transport Cost (US$/year)	0	21,933,222	32,997,843	31,911,776

6. CONCLUSIONS

This paper deals with problems occurred within the fuel oil distribution system in Indonesia undertaken by PERTAMINA Oil Company as a single supplier. The distribution system discussed is the sea-transport mode that occupies almost 80% of total distribution. The proposed approach of analysis includes the visual or map analysis for network justification, distribution network analysis including its consequent costs, and the further financial analysis for policy making toward the final strategies of best delivery.

Results of analysis have produced three possible improvements without and with investment for new facilities (e.g., additional stock tanks and possible replacement of the floating storage with transit terminals). Those proposed improvements appear attractive to reduce total transport cost per year. Although, the third scenario would require large amount of investment cost and less savings in terms of transport cost, it is quite appealing in the long run due to deteriorating condition of the floating storage. Further refinement is expected to confirm with all calculations prior to any adoption, and it seems that the approach is quite promising for any evaluation of existing distribution systems and their post-evaluation.

REFERENCES

Castilho, B.D.. and Daganzo, C. (1993). Handling Strategies for Import Containers at Marine Terminals. Transportation Research, Vol. 27B, No. 2, pp. 151-166.

Daganzo, C. and Newell, G.F. (1993). Handling Operations and the Lot Size Trade-off. Transportation Research, Vol. 27B, No. 3, pp. 167-183.

Frank, S.B., Richard, M., and Thomas, E.V. (1977). **Principle of Operations Research for Management**, Richard D. Irwin, Inc.

Harvey, M.W. (1975). **Principle of Operations Research with Applications to Managerial Decisions**. Prentice-Hall Inc. Englewood Cliffs, New Jersey.

Hausman W.H., Schwarz L.B. and Graves, S.C. (1976). Optimal Storage Assignment in Automatic Warehouse Systems. Management Science, 22, pp. 201-205.

Mulyono (2000). Distribution Optimization for Domestic Oil Supply. Unpublished Master Thesis, University of Indonesia.
Peterson, R. and Silver, E.A. (1979), **Decision Systems for Inventory Management and Production Planning**, John-Wiley, New York.