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the Potential for Regional Cooperation in Fertilizer

A METHODOLOGY STUDY

The ASEAN Group

Prepared
for

WORLD BANK

by

IFDC-T-2

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PREFACE

Interest in fertilizer industry development and regional economic cooperation has high priority with those commissioned to seek alternative solutions to the world food crisis. In this connection, the Consultative Group on Food Production and Investment (CGFPI) requested the International Fertilizer Development Center (IFDC) and the World Bank's Fertilizer Unit to assess the desirability of cooperation among members of the Association of Southeast Asian Nations (ASEAN) in fertilizer industry development. Methodological and analytical assistance of the Development Research Center, International Bank for Reconstruction and Development (IBRD), was sought in order that the most advanced and comprehensive techniques of fertilizer industry investment planning could be employed in meeting the CGFPI request.

Thus, this document is a joint product of the IFDC, IBRD, and the World Bank's Fertilizer Unit. The essential elements of this paper are drawn from a working document drafted by the IBRD in collaboration with the IFDC and the Fertilizer Unit.

Neither this document, nor the study on which it is based, purports to be an exhaustive study of the subject. It is advanced as a preliminary investigation designed to assess the potential gain to be derived from economic cooperation in regional fertilizer industry development. It does not address intra-country distribution considerations but focuses on investment in productive capacity, per se. Extrapolations of the results to specific countries in the absence of a regional cooperation framework are not valid. Likewise, given the time limitation, the results and conclusions presented here should be considered tentative and subject to substantial change with data refinements.

CONTENTS

Summary, Conclusions, and Implications 5
Summary and Conclusions 5
Implications for Future Work 5

Introduction 7

Objectives of the Study 7

Methodology and Assumptions Employed in the Study 7
Model Considerations 8
Investment Requirements, Site Location and Technical Coefficients 8
Estimation of Fertilizer Demand by Region and Market Area 8
Current Regional Production Capacity 10
Regional Raw Materials Available for Fertilizer Production 10
Product Mix Considerations 10
Transportation Alternatives and Freight Rates 12
Alternative Situations Specified for Analysis 12

Results and Discussions 12
Product Process Selection 12
Capacity Expansion 13
Trade Flows 13
Implications for the Transportation System 14

Plausibility of Results 14
Nitrogen 14
Phosphate 15
Potash—Comments 15

Bibliography 19

Appendix 20

TABLES

1 Fertilizer Production Capacity, ASEAN Group, 1975 and 1985 11
2 ASEAN Fertilizer Study: A Summary of the Minimum Cost Solutions, by Scenario, in Million Dollars, 1975 16
3 Estimated Ex-Factory Price of Bulk Urea From Selected Points at 0, 10, and 20% Return on Investment 16
4 Estimated Delivered Price of Bagged Urea From Selected Points to Manila, Philippines Warehouse at 0, 10, 20% Return on Investment 17
5 Estimated Delivered Price of Granular Monoammonium Phosphate From Selected Points to Manila in Bagged Form, ASEAN Study, 1975 17

FIGURES

1 Possible Sites for Fertilizer Production in ASEAN Countries 9
2 Estimated Delivered Price (in 1975 Dollars) of Granular Monoammonium Phosphate to Manila in Bagged Form From Three Locations With 20% Return on Investment 18

ABBREVIATIONS

APO . . . . . Asian Productivity Organization
ASEAN . . . . . Association of Southeast Asian Nations
CGFPI . . . . . Consultative Group on Food Production and Investment
DRC . . . . . Development Research Center
ESCAP . . . . . Economic and Social Commission for Asia and the Pacific
FAO . . . . . Food and Agriculture Organization
IBRD . . . . . International Bank for Reconstruction and Development
IFDC . . . . . International Fertilizer Development Center
TVA . . . . . Tennessee Valley Authority
UNIDO . . . . . United Nations Industrial Development Organization

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

SUMMARY AND CONCLUSIONS

The recent instability in the world fertilizer market and the growing importance of fertilizer as a strategic policy tool has generated interest in developing adequate, dependable, and low-cost fertilizer supply alternatives. Of the alternative solutions, the concept of regional complementation or economic cooperation offers opportunities for substantial gain to areas with key fertilizer raw materials and markets, as well as the necessary attitude towards regional integration.

The ASEAN[1] meets the above criteria for mutual gain by cooperation because of: (1) indigenous supplies of key raw materials (natural gas, sulfuric acid, and potentially exploitable potash deposits); (2) nearby sources of phosphate rock (Australia, Nahru, and Christmas Island); (3) developed and growing markets capable of supporting efficient plant sizes; and (4) the required disposition towards cooperation as demonstrated by the ASEAN charter itself. This investigation was made to demonstrate the potential benefits that could accrue to the region through a regionally harmonized fertilizer capacity expansion policy.

To accomplish this task a mathematical programming model was employed to determine the investment, production, importation, and transportation patterns that minimize the cost of meeting the ASEAN 1985 fertilizer requirements. This involved the selection of plant sites, plant sizes, feedstocks, fertilizer intermediates and end products, and most appropriate transportation patterns under varying degrees of regional economic cooperation and integration.

This preliminary analysis indicates there are significant economic benefits to be derived from a regionally harmonized capacity expansion policy. The benefits can be obtained from efficient utilization of the region's relatively low-cost byproduct sulfuric acid and abundant natural gas supplies, capitalization on the physical geography of the region, and the economic integration of markets which permits exploitation of the economies of size that exist in fertilizer production. For example, full regional cooperation as compared with severely restricted cooperation "saves" $180 million in total initial investment and another $117 million in annual operation cost. Though full regional cooperation minimizes total cost, substantial gains can still be made with limits placed on the degree of cooperation in order that certain national objectives can be met. For example, instead of full regional cooperation, the members of the ASEAN may agree that each country should be 75% self-sufficient in nitrogen but open to free trade for the remaining market share. To do so would "cost" an additional $71 million in total initial investment and $10 million in annual operating costs as compared with full regional cooperation. This arrangement would still save $112 million in initial investment and $8 million in annual operating costs over the severely restricted trade case. It should be noted that in all cases the relaxation of trade restrictions in order to achieve the economies of a more efficient organization and allocation of ASEAN resources increases the dependence on the transportation system.

The results indicate that the optimal product mix for the region is centered about urea and monoammonium phosphate (MAP). (The dominance of MAP over diammonium phosphate [DAP] is marginal and may change when technical coefficients are refined through more detailed study.) Additional static production cost analyses confirm the plausibility of these results, and support the study results which indicate that the advantage of Indonesia in ammonia and urea production and of the Philippines in phosphate production will dominate rational regional industry adjustments to the anticipated 1985 supply-demand situation.

IMPLICATIONS FOR FUTURE WORK

Due to time and financial resource limitations, the analysis conducted was static and for a minimum number of simulated regional economic integration situations. The analysis should be expanded into a dynamic one in order to determine the optimal timing of investment between 1978 and 1985 for a larger number of regional economic integration and trade relationships.

It is also important to explore foreign exchange implications of various programs. The countries concerned may prefer a program which minimizes foreign exchange requirements at a somewhat higher total cost than one which offers lower total costs through higher foreign exchange requirements. It is, therefore, recommended that parameterization studies should be carried out to examine this point.

[1] The ASEAN is composed of the countries of Indonesia, Malaysia, the Philippines, Singapore and Thailand. Due to the relatively limited fertilizer consumption in Singapore, Singapore was grouped with Malaysia for study purposes.

Increased regional integration and trade in fertilizer places substantial emphasis on transportation linkages. The general indications are that the increased flows required for institution of a regional harmonized capacity expansion program offer substantial opportunities for gains from cooperation in other sectors. It is recommended that investigations be undertaken to determine the investment requirements, costs and benefits, and potential of economic integration of alternative transportation systems and arrangements.

Since this analysis focuses on the inter-country distribution systems *in toto*, the implications for intra-country fertilizer distribution systems should be thoroughly investigated. If in-country distribution systems are not in synchronization with a regionally harmonized capacity expansion scheme, most, if not all, of the potential benefits from economic cooperation would be lost.

The recently discovered carnallite deposits in Thailand offer considerable potential for increased regional cooperation. The lack of verifiable data on the potential for commercial exploitation of these deposits precludes quantifying of the probable impact a regional potash supply would have on regional fertilizer adjustments. It is recommended that the economic feasibility of commercially exploiting the deposits be thoroughly examined.

The extent of gains to be made from regional economic cooperation and integration depends on the degree which member governments cooperate with one another. It is recommended that constraints to regional cooperation be investigated and public policymakers made aware of the economic consequences of such impediments.

INTRODUCTION

Indications are that the Association of Southeast Asian Nations (ASEAN) will soon formalize an agreement that will expand trade and grant preferential trading arrangement to member countries. The central thrust of this agreement will be to accelerate the economic growth of the region through trade expansion, economic cooperation, and regional integration.[1]

While the above-mentioned agreement makes no specific reference to fertilizer materials, there is considerable interest by individual ASEAN countries to develop an adequate, dependable, and low-cost fertilizer supply. Due to the recent instability in the world fertilizer marketplace, fertilizer and fertilizer production units have become strategic commodities and important public policy tools. In addition, the demand for fertilizers is expected to grow significantly in the ASEAN, but current installed capacity, together with the capacity expansion currently under way, will almost certainly be inadequate to meet regional fertilizer requirements by 1985. Given the region's indigenous supplies of key fertilizer raw materials (natural gas, sulfuric acid, and potentially exploitable potash deposits) and nearby phosphate rock sources (Australia, Nahru, and Christmas Island), there is a substantial potential gain to be derived from a regionally harmonized capacity expansion policy.

[1] Philippines Business Day International, Volume 1, No. 45, Manila, November 10, 1975.

OBJECTIVES OF THE STUDY

Recognizing that regional investment must be an integral part of any economic union that evolves, if such a union is to benefit each of its members, the general objective of this study is to provide an assessment of benefits that would accrue through regional cooperation. This should be presented in a form policymakers might consider as the most efficient investment programs to follow and still ensure stable and secure supplies of these essential commodities.

The specific objectives required to accomplish this were to:

1. Review the current capability of the region to produce and consume fertilizer.
2. Estimate the probable fertilizer consumption of the region through 1985.
3. Identify alternative strategies member nations might consider in meeting fertilizer requirements, considering the raw material resources of the region.
4. Determine the least cost plant size (capacity), number, location, product mix, and direction and magnitude of trade flows for each alternative strategy identified in (3) above.
5. Quantify the investments required and benefits (to the extent possible) that may accrue to the region under the alternative strategies considered.

METHODOLOGY AND ASSUMPTIONS EMPLOYED IN THE STUDY

Critical to this study was access to reliable current data as well as forecasts that predict what is most likely to happen within the region in the foreseeable future. This information was obtained from a wide range of sources; most notable were: Food and Agriculture Organization (FAO) consumption data; Economic and Social Commission for Asia and the Pacific (ESCAP) data on raw materials, plant capacity (operational and under construction), and fertilizer requirements; TVA-IFDC data on production costs, fertilizer plant processes and investment requirements, fertilizer forecasts, planned construction and site location; and IBRD raw material, finished product, transportation, and handling prices and/or costs. For descriptions of the techniques used to develop the basic data, the reader is referred to the referenced documents.

MODEL CONSIDERATIONS

The success of the study necessitated the determination of the investment, production, importation, and transportation patterns that minimized the cost of meeting the region's fertilizer requirements. This included the selection of plant sites, plant sizes, feedstocks, product mix, and most appropriate transportation patterns.

To achieve the simultaneous specification of the optimum levels for these interdependent variables, a static, cost minimization mathematical programming model was developed and solved by electronic computer.[2] The model incorporates fertilizer nutrient requirement projections to 1985 for marketing regions in each country. The fertilizer industry is described by a set of technical relations that describe the transformation of all relevant raw materials via intermediate products into final fertilizer products. The investment and operating costs to be incurred to carry out these transformations are described for a range of possible plant sizes, and taking into account economies of scale. Actual and potential plant sites are stipulated, and shipment activities are specified that permit raw materials and intermediates to be transported to plant sites. Similarly, a set of shipment activities permits the transportation of finished products from each plant site to each marketing center. When exports and imports are considered, appropriate shipment activities for these are included. Specific assumptions and activities are elaborated on below.

INVESTMENT REQUIREMENTS, SITE LOCATION AND TECHNICAL COEFFICIENTS

Estimates were made of investment requirements for production processes deemed applicable to the region. In addition, sites were selected and additional costs ascribed to those areas either already having a fertilizer unit in place or identified from previous work as having potential for development (see figure 1 for site locations). A summary of plant capacity utilization, maximum single-train capacity, and investment requirements used in the study are summarized in appendix table 1. To these investment costs, location-site factors (appendix table 2) were applied to obtain the total investment. Location-site factors cover the additional infrastructure such as site preparation, construction equipment, civil works, piers and jetty, and housing that would be needed to support the complex.

Labor was assumed variable with capacity. Power costs (electricity, steam, etc.) used in production cost calculations reflect only the energy costs for gas or oil assumed to be available at each particular site. Capital charges for production of utilities were included in investment related costs. (Investment requirements reflect these considerations.) Specific assumptions or inputs per metric ton (mt) of product are shown in appendix table 3.

ESTIMATION OF FERTILIZER DEMAND BY REGION AND MARKET AREA

Numerous forecasts for fertilizer use have been developed for the region. Several of these differ little from each other. Estimates made by IBRD, TVA-IFDC, and FAO, in particular, had a high degree of similarity. It was felt that whatever variation existed between forecasts would have little effect on the conclusions reached. Consequently, it was decided to use TVA-IFDC data regarding total demand for the region as well as for specific marketing zones within countries.

Demand projections for 1985 by region and by country (Singapore is grouped with Malaysia) were made at two levels (low and high) for nitrogen, and one level each for phosphate and potash. An additional level for nitrogen, the "recommended level" was projected for Indonesia. Fertilizer consumption forecasts to 1985 for eight market regions in Indonesia, three in the Philippines, two in Malaysia, and one in Thailand are summarized in appendix table 5.

Essentially, the "recommended level" refers to that amount of fertilizer needed to achieve self-sufficiency, assuming present population growth rates continue in Indonesia through 1985. In all cases, the "high" demand level was used in the study. This was the amount of fertilizer needed to achieve self-sufficiency in food production for Malaysia and the Philippines. In the case of Indonesia, the high represents 95% self-sufficiency in rice. It is assumed that Thailand, and not some source outside the region, will meet the additional food needs of Indonesia and Singapore; hence a high fertilizer demand rate was also used for Thailand.

In general, 1985 nutrient use was estimated to be 2,240,000 mt, 690,000 mt, and 490,000 mt of N, P_2O_5 and K_2O, respectively. This represents an approximate threefold increase in fertilizer use in the next decade. Indonesia with its population and size will be the prime consumer of nitrogen and phosphate; and Malaysia, because of its expected continued heavy emphasis on industrial crops, is forecast to be the prime user of potash.

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[2]Details of the study and the model can be found in: Alexander Meeraus, et al., Regional Investment Planning: The Case of the South-East Asian Fertilizer Industry, DRC, IBRD, October 1975 (preliminary draft) and Armeane M. Choksi, et al. "The Planning of Investment Programs in the Fertilizer Industry" in The Planning of Investment Programs, Vol. III, by A. Stoutjesdijk, Washington, D.C.: DRC, IBRD, September 1975 (revised draft).

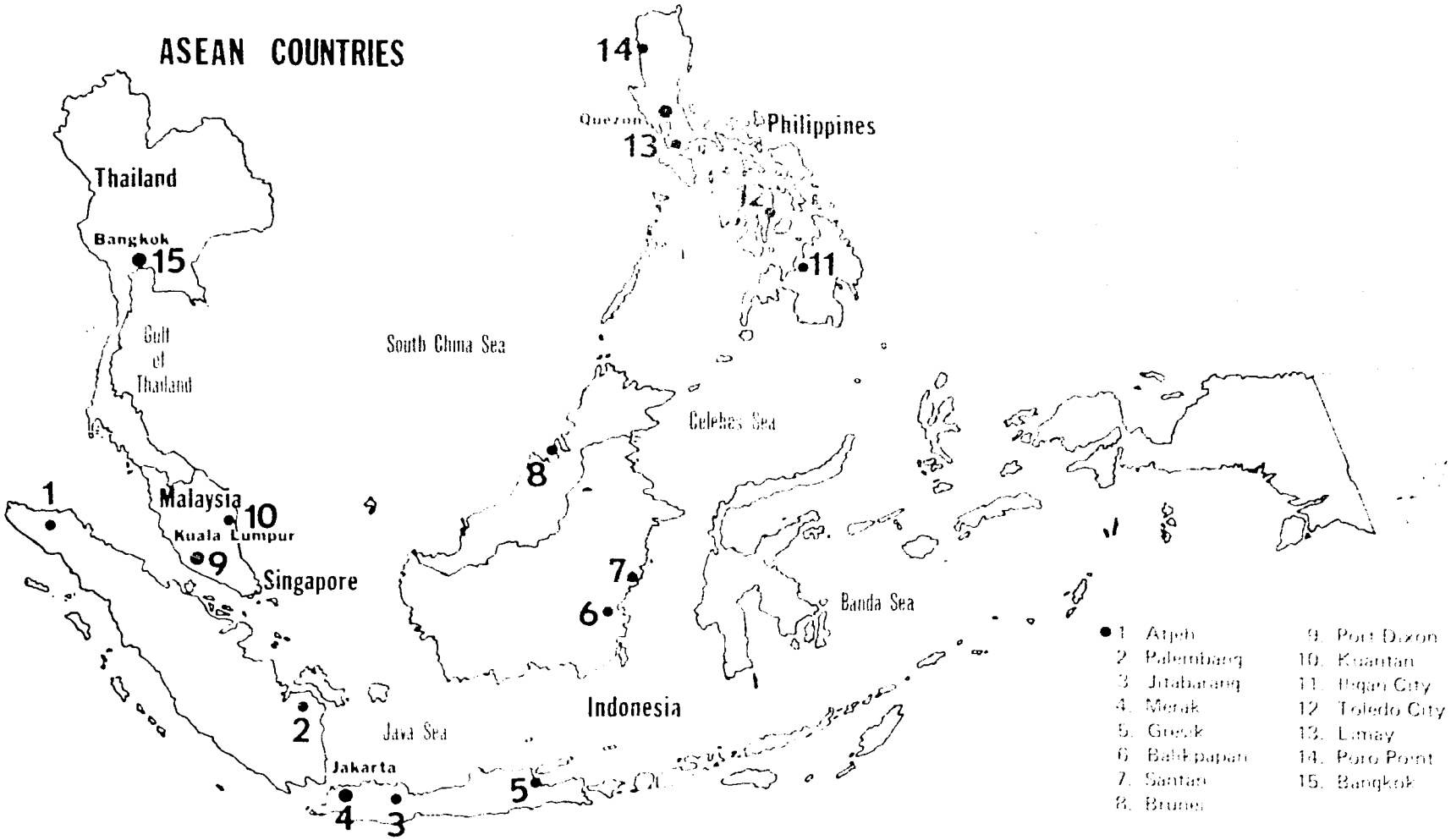

Figure 1. Possible sites for fertilizer production in ASEAN countries

While it may be argued that lower demand projections for nitrogen and phosphate may be justified under normal circumstances, the high range of the forecast was used for purposes of presenting the plant investment required for the most optimistic yet attainable demand levels for the region. Additional analyses could be made using the low (likely attainable) levels, but would represent refinements beyond the scope of this preliminary investigation.

CURRENT REGIONAL PRODUCTION CAPACITY

The current (1975) productive capacity and the likely 1985 status of these facilities are summarized in table 1. Plants operating by 1970 or before were assumed to have a 15-year life and thus were considered closed by 1985. By 1985, 91% of the 1975 installed ammonia-nitrogen capacity of Indonesia will remain, including the startup of PUSRI III at Palembang in 1977 and at Gresik the heavy oil based plant producing urea and ammonium sulfate. The combined capacity of nitrogen of 177,000 mt/year now installed and operating in Malaysia, Thailand, and the Philippines was phased out. Of a total regional ammonia-nitrogen capacity in 1975 of 734,000 mt, only 508,000 mt (69%) will be operating, all of this based in Indonesia. The existing nitrogen capacity available for 1985 will primarily produce urea with a minor amount as ammonium sulfate.

The current phosphoric acid capacity of 79,000 mt P_2O_5/year in the Philippines was assumed to be phased out by 1985; plants for TSP, SSP, and complex fertilizers were also phased out.

Currently in Indonesia, an ammonia-urea complex at Palembang at 271,000 mt N/year is under construction. A similar size plant, or perhaps slightly larger, is reported to be under consideration (although it was not included in the model as "firmly planned capacity" as of this date). Additionally, the so-called "floating fertilizer plant at Santan Kalimantan" was not considered as "planned and under construction." The Philippines is now conducting feasibility studies of an ammonia-urea complex and a phosphate complex. Neither of these was considered "firm and under construction."

Thailand is bringing on-stream a fertilizer plant with a rated capacity of 100,000 mt/year of 18-22-0 based on imported intermediates. This capacity was not included. Exclusion of this capacity should not affect results and represents downstream facilities that should be included in extensions of the present study.

REGIONAL RAW MATERIALS AVAILABLE FOR FERTILIZER PRODUCTION

Nitrogen Feedstock

Based on modern technology, natural gas is the preferred feedstock for the production of ammonia when compared with naphtha, fuel oil, coal, or electrolysis. Only two countries in the ASEAN region, Indonesia and Malaysia (plus Brunei), have substantial quantities of natural gas on which to base a nitrogen industry. A plant built in the Philippines or mainland Malaysia would require naphtha or fuel oil. Where gas was available but limited, a maximum capacity expansion restriction was imposed. The lower natural gas price of $0.60/1,000 ft^3 reflects a deposit and site not having an opportunity for industrial usage such as liquefied natural gas (LNG) or steelmaking. For purposes of the study, gas was assumed to have a heating value of 1,000 Btu/ft^3, free of impurities and available to the plant battery limits at 600 psig; actual gas compositions for the individual sites were not available. Fuel oil could be imported to all locations to produce ammonia at an $85/mt price. Appendix tables 6 and 7 summarize natural gas availabilities and prices and prices of other raw materials by site location as employed in the study.

Phosphate Raw Materials

The ASEAN region has very limited phosphate raw materials. Generally, the phosphate rock and sulfur, basic raw materials for phosphate production, must be imported at all locations, except in Toledo City and Poro Point. At these sites considerable low-cost byproduct sulfuric acid is available from copper smelting (appendix table 7). Prices used for sulfur and rock were $60/mt and $50/mt, respectively; byproduct sulfuric acid was considered available at $10/mt. The restraint on availability of acid was relaxed for selected phases of the analysis, since the potential exists for additional copper smelting capacity to be built in the Philippines. To get a perspective on the sulfuric acid quantity for phosphate production, 1.49 mt of 100% sulfuric acid will produce 1.0 mt of phosphoric acid. Therefore, at Poro Point, 250,000 mt sulfuric acid (amount to be available by 1977) is equal to 167,785 mt of phosphoric acid or about 91,000 mt/year of P_2O_5 (275 mt/day). At Toledo City, about 197,000 mt/year of P_2O_5 (about 600 mt/day) could be produced from the sulfuric acid that will be available at that site by 1977.

Potash Raw Materials

The only known potential potash raw material in the region is a newly discovered carnallite deposit in Thailand. Carnallite is a potassium chloride-magnesium chloride salt and technology is available for recovering the separate salts. The extent of the carnallite reserves is not known at this time.

PRODUCT MIX CONSIDERATIONS

For a variety of technical and computational considerations, limits were placed on the alternative types of production processes (urea, MAP, DAP, etc.) and grades of imported (from outside the region) materials incorporated into the model representation of the regional fertilizer industry. Imports to satisfy regional demand were

Table 1. Fertilizer Production Capacity, ASEAN Group, 1975 and 1985[a]

Country (Region)	Location	Ammonia Start up Year	Ammonia Capacity[b] 1975	Ammonia Capacity[b] 1985	Urea Start up Year	Urea Capacity[b] 1975	Urea Capacity[b] 1985	Ammonium Sulfate Start up Year	Ammonium Sulfate Capacity[b] 1975	Ammonium Sulfate Capacity[b] 1985	Sulfuric Acid Start up Year	Sulfuric Acid Capacity[b] 1975	Sulfuric Acid Capacity[b] 1985	Phosphoric Acid Start up Year	Phosphoric Acid Capacity[b] 1975	Phosphoric Acid Capacity[b] 1985	Single Superphosphate Start up Year	Single Superphosphate Capacity[b] 1975	Single Superphosphate Capacity[b] 1985	Triple Superphosphate Start up Year	Triple Superphosphate Capacity[b] 1975	Triple Superphosphate Capacity[b] 1985	Complex Fertilizer Start up Year	Complex Fertilizer Capacity[b] 1975	Complex Fertilizer Capacity[b] 1985
Indonesia	Palembang	1963	49	–	1963	45																			
(Sumatra)		1974	179	179	1974	170	170																		
		1977	271	271	1977	256	256																		
(E. Java)	Gresik	1972	58	58	1972	29	29	1972	24	24	1972	90	90												
Indonesia Total		–	557	508	–	500	455	–	24	24	–	90	90												
Malaysia	Port Dixon	1966	41	–	–	–	–																1966	200	–
(West)	Petaling Jaya	–	–	–	–			1970	8																
Malaysia Total		–	41	–	–	–	–		8														–	200	–
Thailand	Mae Noh	1967	27	–	1967	14	–	1967	13																
	Bangkok	–	–	–	–																		1975	100	100
Thailand Total		–	27	–	–	14	–	–	13	–	–	–	–	–	–	–	–	–	–	–	–	–	–	100	100
Philippines																									
(Mindanao)	Iligan City	1966	27	–		–	–	1954	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
(Cebu)	Toledo City	–	–	–	–	–	–	1966	17	–	–	–	–	1958	10	–	1958	7	–	1958	10	–	1958	300	–
(Luzon)	Limay	1965	82	–	1966	31	–	–	–		–	–	–	1966	69	–	–	–	–	–	–	–	1966	243	–
	Rizal	–	–	–	–	–	–	1965	13	–	–	–	–	–	–	–	1965	3	–	–	–	–	–	–	–
Philippines Total		–	109	–	–	31	–	–	40	–	–	–	–	–	79	–	–	10	–	–	10	–	–	443	–
ASEAN Total		–	743	508	–	545	455	–	85	24	–	90	90	–	79	–	–	10	–	–	10	–	–	743	100

[a]Includes existing and firmly planned facilities as of October 1975.

[b]Capacity is measured in terms of primary nutrient content except in the case of sulfuric acid and complex fertilizer, where product units are used. As plants are assumed to have a maximum life of 15 years, capacity installed in 1970 or before is not assumed to be available in 1985. The capacity figures for 1985 include capacity currently under construction.

Source: TVA capacity data file.

limited to triple superphosphate (TSP), diammonium phosphate (DAP), and potassium chloride. The production process alternatives employed in the model included: ammonia (natural gas and fuel oil based units); urea; ammonium sulfate (prime and byproduct); granular monoammonium phosphate; diammonium phosphate; single superphosphate (SSP); triple superphosphate (TSP); ammonium polyphosphate (APP); urea-ammonium phosphate (UAP); phosphoric acid; and sulfuric acid. The chemical analysis, product mix considerations, and appropriate import prices are presented in appendix table 9.

Nitrate-based fertilizers were eliminated because trends of the region indicate a pronounced movement towards urea and ammonium sulfate. For this phase of the study, the production of complex NPK products by granulation or bulk blending was not considered. If desirable, additional studies could be conducted which consider a wider range of final product mixes and downstream processes including relatively new materials (to the region) such as: granular urea; powdered monoammonium phosphate; ammonium phosphates (MAP or DAP) by new process technology not incorporated here; mixed fertilizers by granulation, blending or as liquids; and improved efficiency materials (nitrogen and phosphate). Such extensions were beyond the scope of this work.

TRANSPORTATION ALTERNATIVES AND FREIGHT RATES

Given that the basic objective of this investigation was to evaluate alternative fertilizer capacity expansion strategies, and in consideration of the physical geography of the study area, it was recognized that inter-country transport of raw materials, intermediates, and finished products would be dominant considerations. Thus, all raw material, intermediate product and final product flows between appropriate points are assumed to be bulk shipments. Appropriate adjustments were made in plant investments and operating costs to reflect final product bagging requirements. The only regional intermediate product shipping alternatives considered were ammonia and phosphoric acid. To reflect storage and handling costs of ammonia and phosphoric acid, a charge of $10 and $5 was added, respectively, to the base schedules.

The shipping rate schedules utilized were based on previous IFD/DRC (IBRD) world fertilizer study with appropriate adjustments. The schedules employed are as follows:

a. bulk final products: Cost, $/mt = 4.6 + (.00125 x miles)
b. ammonia: Cost, $/mt = 2.7 + (.0029 x miles) + 10
c. phosphoric acid: Cost, $/mt = 3.6 + (.0035 x miles) + 5

ALTERNATIVE SITUATIONS SPECIFIED FOR ANALYSIS

In order to measure the effects of (1) varying degrees of regional cooperation, and (2) various raw material constraints on efficient use of the region's fertilizer production resources, six different situations or scenarios were specified. The situations were defined for the degree of regional cooperation as specified by varying amounts of indigenous N or P production, simulation of plant construction at the Jatibarang site, and by-product sulfuric acid availability. Each situation as specified and designated as Scenario A through F is summarized in the table below and used throughout the remainder of this study.

Scenario Identification	A	B	C	D	E	F
Self-sufficiency (maximum supply of raw materials)	None	75% N	75% N	None	75% N	100% N and P_2O_5
Sulfuric acid ex-smelting	Unlimited	Unlimited	Limited	Limited	Limited	Limited
Production at Jatibarang	No	No	No	No	Yes	No

RESULTS AND DISCUSSIONS

PRODUCT PROCESS SELECTION

For all scenarios, urea was preferred over ammonium sulfate; ammonium sulfate was rejected because of its low analysis and relatively high production cost per unit of nutrient. Monoammonium phosphate was selected over diammonium phosphate because for a given plant size and investment, the former results in a higher operating rate (preneutralizer-rotary drum process). In addition, less

energy is needed (thus lower cost) to dry monoammonium phosphate; in addition, it can be dried at a higher temperature than DAP. The optimal product mix was the same in all scenarios, but the actual quantities produced and locations varied.

CAPACITY EXPANSION

In general, relaxation of trade restrictions reduced the total annual cost and total investment requirements while increasing the dependence on the transportation system in order to achieve the economies accessible through a more efficient organization and allocation of ASEAN resources (table 2). Cursory examination of the results reveals the regional comparative advantage of Indonesia and the Philippines in the production of nitrogen and phosphatic materials, respectively. While selective imposition of restraints to economic integration of the regional fertilizer industry or domestic raw materials produces deviations from this pattern, the impact of relatively inexpensive sulfuric acid from Philippine smelting operations and Indonesian natural gas dominate rational regional fertilizer industry adjustments to the expected 1985 demand situation. This preliminary analysis indicates that in order to meet 1985 requirements, the ASEAN region will have to import or make capacity additions of 2,693,000 mt/year of ammonia, 4,123,000 mt/year of urea, 1,265,000 mt/year of phosphoric acid, and 1,022,000 mt/year of ammonium phosphates. This corresponds to 2,099,440 mt of N and 690,012 mt of P_2O_5. Depending on the degree of regional economic integration, this capacity expansion would require an investment ranging from $1,370 million to $1,553 million.

Under full regional cooperation, nitrogen requirements are met by ammonia and urea expansions at the Palembang and Balikpapan sites. With unlimited byproduct sulfuric acid, Poro Point and Toledo City sites capture all phosphoric acid and phosphatic final materials (MAP with Balikpapan ammonia) (Scenario A). With limitations on byproduct sulfuric acid to currently planned expansions but with full regional cooperation (Scenario D), sulfuric acid (from imported sulfur), phosphoric acid, and final product (MAP) capacities are added at Gresik and Bangkok (appendix tables 10 and 13).

Imposition of a constraint on regional cooperation which requires that 75% of each country's nitrogen requirement must be produced locally (Scenario B) changes the capacity expansion program substantially with attendant increases in regional fertilizer industry investment. In comparison with Scenarios A and D discussed above, the Palembang expansions are retained, but Balikpapan capacity is dramatically curtailed. This capacity is offset by natural gas-based ammonia-urea units being erected at Bangkok and Toledo City to satisfy Thai and Philippine nitrogen requirements. There is no change in the phosphate production program. With byproduct sulfuric acid limitations and the 75% locally produced N requirement imposed (Scenario C), Toledo City's sulfuric acid capacity is expanded via imported sulfur and phosphoric acid capacities are reduced at Gresik and Bangkok (appendix tables 11 and 12).

The "forcing-in" of an ammonia-urea complex (Scenario E) at the Jatibarang, West Java, site results in a reduction in ammonia capacity constructed at Balikpapan and MAP (and corresponding sulfuric and phosphoric acid adjustments) expansions at Gresik and Bangkok at the expense of Toledo City (appendix table 14).

The most expensive capacity expansion program is incurred when each country must supply both N and P_2O_5 from domestic plants and no shipments of intermediates or finished materials occur—i.e., Scenario F (appendix table 15).

TRADE FLOWS

Given the nature of the solution procedure, the minimization of total cost with the simultaneous consideration of investment, import, production, and transportation factors, the resulting raw intermediate and final product flows are essential features of any regional cooperation scheme.

In the interest of brevity and clarity, this paper will only examine the product flows of Scenarios A, C, and E, since D and B are minor variations of A and C, and F, by definition, precludes shipments. Consistent with the full regional cooperation and unlimited byproduct sulfuric acid capacity expansion solutions (Scenario A) discussed earlier, Indonesia is the exporter of ammonia and urea and the Philippines are the suppliers of phosphate materials. Balikpapan supplies the ammonia to the Poro Point and Toledo City MAP plants (appendix tables 16 and 23). Palembang supplies urea to the North and South Sumatra markets and the West Java urea market is shared between Palembang (the dominant supplier) and Balikpapan. In all other demand regions, Balikpapan is the dominant supplier of nitrogen (appendix figure 2).

From the phosphate standpoint, Toledo City is the dominant supplier except to North and South Sumatra, Northern Philippines, and Thailand, where the supply is dominated by the Poro Point plant.

As with capacity expansion, institution of a constraint that 75% of the N requirement must be locally produced and the placement of limits on the supply of sulfur have pronounced effects on trade flows. Palembang continues to supply North and South Sumatra and captures all of West and Central Java and a portion of East Java from

Balikpapan, but in turn relinquishes all of West Malaysia to the Kuantan site and most of the Thailand market to Bangkok and Kuantan sites. Balikpapan capacity is reduced by one-half with the Toledo City expansion capturing the Northern and Central Philippines demand regions from Balikpapan (appendix tables 18 and 24). Due to rigid enforcement of the "75% rule," and the small existing plant at Gresik, an optimal solution indicates that Toledo City should ship approximately 22,000 mt of ammonia per year to Gresik. Very small reductions in the "75% rule" or sulfuric acid limitations would result in reallocation of the market share to an Indonesian ammonia plant, probably Balikpapan. From the phosphate point of view, the Toledo City site continues to dominate though capacity is essentially halved. The Gresik capacity secures its market volume in East and Central Java and a portion of the West Java market from the Toledo City facility. The Bangkok capacity is gained at the expense of both Poro Point and Toledo City. Aside from the reductions in capacity size at Poro Point and Toledo City, Poro Point's South Sumatra market is captured by the Toledo City site (see also appendix figures 2-6).

Forcing-in of an ammonia plant at the Jatibarang site while observing the "75% rule" on nitrogen and limitations on sulfuric acid availability results in a trade flow pattern similar to Scenario C. Jatibarang ammonia expansion is at the expense of Balikpapan which in turn results in Jatibarang urea market growth in Central Java at Palembang expense, but with Palembang demonstrating its site advantages by recapturing this volume from Balikpapan in East Java. On the phosphate side, both Gresik and Bangkok experience slight increases in capacity at the expense of Toledo City (see appendix tables 20 and 25 and appendix figures 3-7).

IMPLICATIONS FOR THE TRANSPORTATION SYSTEM

While the results presented have had implied effects on the transportation system, it is helpful at this point to quantify some of these implicit flows in order to gain some insight into the magnitude of the logistics problem to be encountered. From a raw materials standpoint, phosphate rock appears to be the most demanding. Assuming shipments of 25,000 tons/ship, Poro Point and Toledo City facilities would require 31 and 62 ship loads annually under Scenario A. At the Toledo City facility, this will mean a turn-around time of less than five days on each ship or approximately a continuous uninterrupted unloading rate of 4,300 tons per day. While systems to handle such quantities are common, careful planning will be required to ensure that adequate handling, and storage capacity is available when the system hits peak levels. Though phosphate rock appears to be most demanding, consideration must be given to raw material and intermediate product handling and storage problems, most notably ammonia. The ammonia requirements of Scenario A for the Poro Point and Toledo City plants will require approximately [illegible] shipments of 10,000 tons each. While not overly demanding requirements, they do offer substantial opportunity for identifying additional economies that may be captured through product movement coordination.

The greatest stress is placed on the transportation system by the shipment of final product under Scenario A. For example, Balikpapan shipments of 2,833,000 tons per year would require 405 vessels of 7,000 tons each and a loading rate of approximately 1.1 ships per day. The sea transport requirements of distributing the phosphate materials are not as large but these would require approximately 138 loads of 7,000 tons each. In total, 543 hauls would be required to facilitate the trade that would be generated.

While this exercise on the transportation implications is not definitive, nor does it estimate the attendant investments that implementation of any regional trade program would necessitate, it does serve to emphasize that capacity expansion plans cannot be made in isolation from physical distribution considerations.

PLAUSIBILITY OF RESULTS

As presented, the results did not include product production costs in tabular form, as these were calculated and employed internally by the model. Therefore, it was not possible to determine whether capacity and site location decisions were marginal or could easily be justified against competition from outside the region. It was felt that an inspection of static production costs of ammonia, urea, and monoammonium phosphate at key sites within the region and at likely competitive sites outside the region would provide at least a partial answer to this question.

NITROGEN

Production costs were estimated for the production of ammonia-urea from natural gas and fuel oil at Palembang

Toledo City, and the Persian Gulf. It was felt that with low-cost gas, the Persian Gulf is a potential nitrogen supplier to the region in 1985. Manila was selected as the receiving point for the product; urea is shipped in bulk and bagged at the port. Internal handling and distribution costs were added to obtain a C.I.F. warehouse price for 50 kg bagged urea. Production costs and prices are expressed in 1975 dollars. The freight rates presented in appendix table 27 for shipment of bulk product from selected ports to Manila were calculated on the same schedule as used in the model.

Plant investments used in calculation of production cost at the various locations are given in appendix table 28. Investment is in 1975 prices with no escalation included (instantaneous erection) and approximates values used in the model. Production cost for ammonia at Palembang and the Persian Gulf was equal when gas at Persian Gulf was $.50/1,000 ft^3, but about $14/mt less in the Gulf with $.10 gas. Ammonia was slightly higher at Balikpapan when compared with Palembang because of additional infrastructure required. Production cost for ammonia was highest at Toledo City due to the high feedstock cost. Essentially the same relationship was true when ammonia at each location was converted to urea, bulk basis.

The ex-factory prices for bulk urea at each location at 0-, 10-, and 20-percent return on investment are presented in table 3.

In order to determine delivered prices for bagged urea certain handling, freight and distribution costs were synthesized (table 4). The comparison reveals that Palembang could provide urea at a slightly lower price to Manila when compared with Balikpapan at the same ROI. Urea, based on fuel oil, proved to be more expensive than that made from natural gas, and does not begin to compete with other urea sources, even at no ROI. It appears that the Persian Gulf could compete in the region by pricing gas at $.25/1,000 ft^3 or below. The assumed C.I.F. price of $200/mt used in the model appears to be indicative of Persian Gulf material moving into the region. Thus, the study results in terms of nitrogen appear to be plausible.

PHOSPHATE

Similar type calculations were made for phosphorus to determine how granular monoammonium phosphate produced in the region would compete with MAP from Florida and/or Morocco. Byproduct sulfuric acid was assumed available at Toledo City; in Florida and Morocco sulfuric acid was produced from elemental sulfur. Table 5 summarizes MAP production costs with the levels of sulfur and rock prices for Philippine, Florida, and Moroccan sites; ex-factory price includes a 20-percent return on investment. Toledo City has a cost advantage due to the byproduct sulfuric acid and represents the lowest ex-factory price for MAP except for that produced in Florida using $30 rock and sulfur. Figure 2 can be used to estimate the delivered price of granular MAP to Manila at other levels of rock and sulfur cost. The data clearly demonstrate the advantage of byproduct sulfuric acid for Toledo City. It can be concluded that with a 20-percent return on investment, MAP will be expensive when delivered to the region. In the study, the DAP price to the region was $250 C.I.F. or $390.6/mt of plant nutrient. Estimated production cost of MAP (11-54-0) at Toledo City was $209.4/mt or $332.2/mt of plant nutrient. Similar calculations for granular DAP indicate a slightly higher cost as compared with MAP. Therefore, based on the specific assumptions used in the study, the selection of MAP over DAP is rational. In either case, it appears Toledo City and Poro Point should utilize its byproduct sulfuric acid for the production of phosphates. It can be concluded that the data used in this study are relative and a phosphate industry established in the Philippines should be able to compete within the region against outside sources.

POTASH–COMMENTS

As mentioned previously, Thailand has some potential for providing potash to the region from carnallite deposits. It was beyond the scope of this paper to investigate the economics and technical feasibility of exploiting the deposit. In fact, little data could be found concerning the deposit. Carnallite is a salt consisting of potassium and magnesium chloride ($KCl \cdot MgCl_2 \cdot 6H_2O$). Based on the lack of data, it appears that a detailed research project, from fundamental through pilot plant level, would be required to assess the potential of Thailand carnallite ore. One intriguing possibility is the thermal decomposition into potassium chloride with the byproduct hydrochloric acid and magnesium used for processing of phosphate rock into fertilizer.

The model was not expanded to consider investment and capacity needs related to potash. These alternatives could not be incorporated into the model because of data and time limitations.

Even so, potassium demand within the region is substantial and investment requirements to develop the deposits in Thailand could represent a significant component of any regional program. To illustrate this potential, demand for muriate of potash (0-0-60) in the region is estimated to be about 816,000 mt in 1985. Of this, approximately 50 percent (400,000 mt) is forecast to be needed by Malaysia, and more than 95 percent of that in Western Malaysia.

The remaining 416,000 mt is divided equally among Thailand, the Philippines, and Indonesia. Assuming all the

Table 2. ASEAN Fertilizer Study: A Summary of the Minimum Cost Solutions, by Scenario, in Million Dollars, 1975

Scenario Identification	A	B	C	D	E	F
Self sufficiency (minimum domestic supply of raw materials)	none	75% N	75% N	none	75% N	100% N 100% P_2O_5
Sulfuric acid ex-smelting	unlimited	unlimited	limited	limited	limited	limited
Production at Jatibarang	no	no	no	no	yes	no
Annual investment charges[a]	191	203	213	200	211	216
Imports a) final products[b]	49	49	49	49	49	49
b) raw materials	119	177	202	144	202	236
Domestic raw materials and by-products	79	75	64	68	75	54
Operating costs	199	209	213	202	214	21
Sea transport	34	25	22	30	19	15
Total Annual Cost	**671**	**738**	**763**	**693**	**772**	790
Total Investment	**1,370**	**1,441**	**1,517**	**1,441**	**1,503**	1,553

[a]Including working capital.
[b]This item refers to potash requirements, and represents the sales in the region of product from the proposed potash development in Thailand

Table 3. Estimated Ex-Factory Price[a] of Bulk Urea from Selected Points at 0, 10, and 20% Return on Investment

Location:	% ROI on urea	Palembang Natural gas @ $0.60			Balikpapan Natural gas @ $0.60			Toledo City Fuel oil @ $85			Gas @ $.10			Persian Gulf Gas @ $.25			Gas @ $.50		
% ROI on ammonia		0	10	20	0	10	20	0	10	20	0	10	20	0	10	20	0	10	20
		$/mt.																	
Palembang $0.60 gas	0	81	102	124															
	10	95	117	139															
	20	109	132	155															
Balikpapan $0.60 gas	0				84	107	129												
	10				99	122	146												
	20				114	138	163												
Toledo City Fuel oil at $85	0							133	162	191									
	10							150	179	209									
	20							166	196	227									
Persian Gulf $0.10 gas	0										71	93	116						
	10										86	109	132						
	20										100	124	148						
Persian Gulf $0.25 gas	0													75	97	120			
	10													89	113	136			
	20													105	129	152			
Persian Gulf $0.50 gas	0																81	104	127
	10																104	120	143
	20																111	135	160

[a]Estimated as 1975 dollars.

Table 4. Estimated Delivered Price[a] of Bagged Urea From Selected Points to Manila, Philippines Warehouse at 0, 10, 20% Return on Investment

Location[b]	% ROI on urea	Palembang[c] Natural gas @ $0.60			Balikpapan[d] Natural gas @ $0.60			Toledo City[e] Fuel oil @ $85			Persian Gulf[f] Gas @ $.10			Persian Gulf[f] Gas @ $.25			Persian Gulf[f] Gas @ $.50		
% ROI on ammonia		0	10	20	0	10	20	0	10	20	0	10	20	0	10	20	0	10	20
		$/mt																	
Palembang $0.60 gas	0	140	162	183															
	10	155	177	199															
	20	169	192	215															
Balikpapan $0.60 gas	0				143	166	189												
	10				158	182	205												
	20				173	198	222												
Toledo City Fuel oil at $85	0							192	221	249									
	10							208	238	267									
	20							224	254	285									
Persian Gulf $0.10 gas	0										135	158	180						
	10										150	173	196						
	20										165	188	212						
Persian Gulf $0.25 gas	0													139	162	184			
	10													154	177	200			
	20													169	193	217			
Persian Gulf $0.50 gas	0																145	168	191
	10																168	184	207
	20																175	200	224

[a]Estimated as 1975 dollars.
[b]Price includes a fixed charge of sales and administrative expense, $15; factory to port freight, $5; loading bulk, $2; discharge bulk, $2; bags, $9; freight to warehouse, $20 plus variable ocean freight cost depending on distance. Fixed charge = $53.
[c]Palembang to Manila total = $59.81/mt.
[d]Balikpapan to Manila total = $59.39/mt.
[e]Toledo City to Manila total = $58.15/mt.
[f]Persian Gulf to Manila total = $64.16/mt.

Table 5. Estimated Delivered Price[a] of Granular Monoammonium Phosphate From Selected Points to Manila in Bagged Form, ASEAN Study, 1975

	Toledo City[c]	Florida[d]				Morocco[e]			
Sulfur, $/mt	Byproduct sulfuric acid at $10/mt	30	70	70	30	30	70	70	30
Rock, $/mt	50	30	70	30	70	30	70	30	70
Ex-factory price at 20% ROI, $/mt	234	221	333	247	307	243	355	269	329
Fixed charge,[b] $/mt	58.2	70.9	70.9	70.9	70.9	67.6	67.6	67.6	67.6
Delivered price, $/mt CIF warehouse, Manila	292.2	291.9	403.9	317.9	377.9	310.6	422.6	336.6	396.6
$/mt nutrient (11-54-0)	449.5	449.1	621.4	489.1	581.4	477.8	650.2	517.8	610.2

[a]In 1975 dollars.
[b]Fixed charge consists of: sales and administrative expense, $15; freight factory to port, $5; bulk loading, $2; bulk discharge, $2; bags, $9; inland freight to warehouse, $20 plus a variable ocean freight cost; subtotal = $53.
[c]Toledo City to Manila = $5.15/mt
[d]Florida to Manila = $17.86/mt.
[e]Morocco to Manila = $14.60/mt.

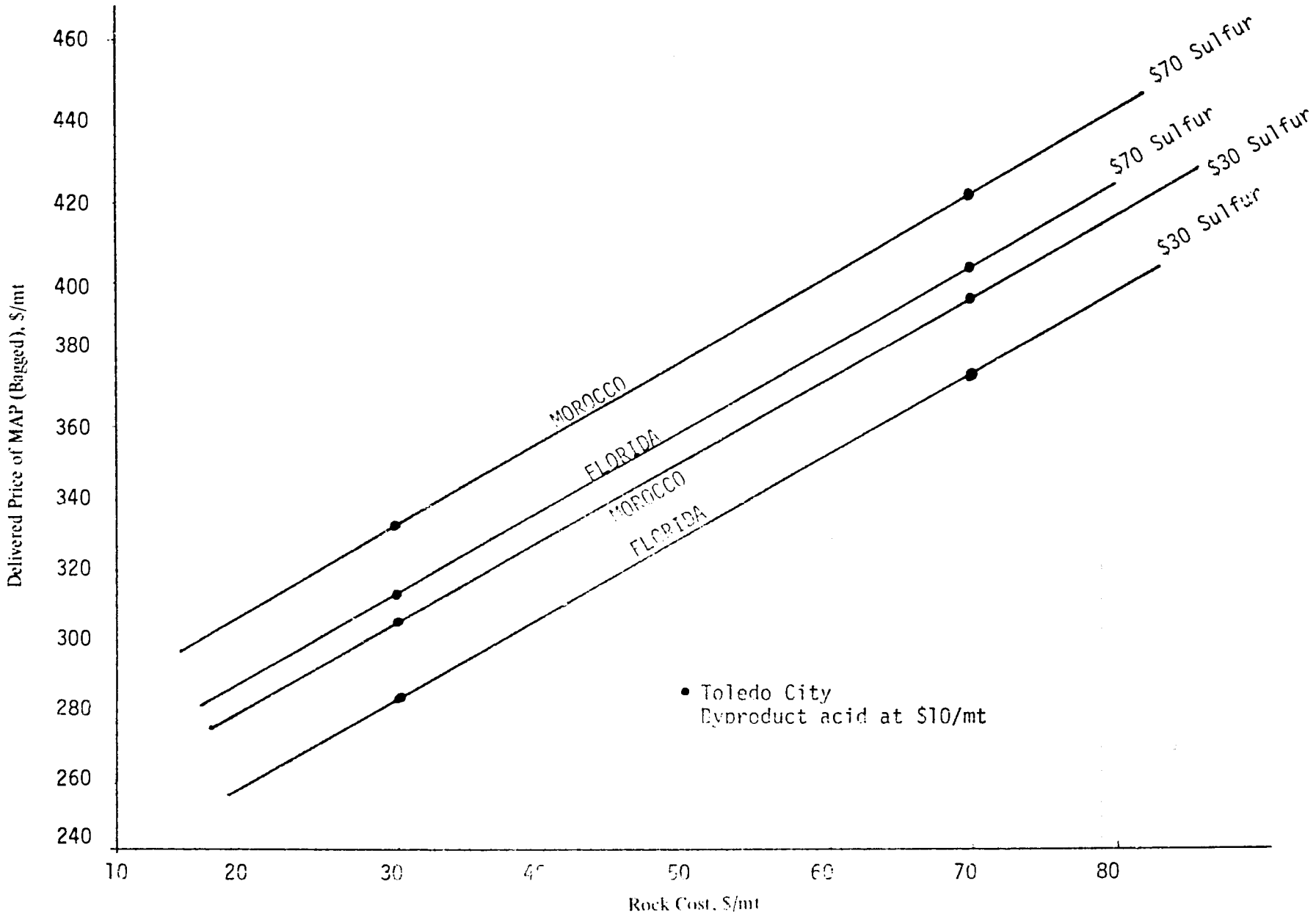

Figure 2. Estimated Delivered Price (in 1975 Dollars) of Granular Monoammonium Phosphate to Market in Bagged Form From Three Locations With 20% Return on Investment.

potash for the region will come from Thai deposits and the Thai component does not move by ship, approximately 97 shiploads of 7,000 mt each would leave Bangkok annually, or about one ship every four days.

The exact distribution points for potash could not be established in this study because the model did not include NPK production activity (blended or granulated) with potash used as straight material. Such decisions can only be made when more information is available about distribution costs and specific market requirements within each country. Future studies should address these issues.

In addition, investigations need to be made in determining whether the carnallite deposits in Thailand can be developed if an annual market of 800,000 mt of product is reasonably assured by 1985.

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Appendix Table 1. Summary of Alternative Process Characteristics and Estimated Investment Requirements, ASEAN Study, 1975

Process	Ammonia Nat.gas	Ammonia Fuel oil	Urea[a]	Ammonium Sulfate (Prime)	Sulfuric Acid	Phosphoric Acid	MAP[b]	DAP[b]	APP[b]	SSP[b]	TSP[b]
Capacity, mt/day (maximum per single-train)	1100	1100	1800	700	1400	1000	1000	1000	1000	2000	1400
Capacity, Utilization, %	89	89	89	100	100	100	125	100	100	100	100
Plant investment, $/MM[c]	86.0	112.2	48.1	10.7	24.0	29.0	15.3	15.3	14.6	24.5	23.0

[a]As prilled urea.

[b]As granular products.

[c]All costs in 1975 dollars includes battery limits, auxiliary and support facilities, spare parts, training, startup, 15-day ammonia and acid storage, 45-day bulk storage and 20-day bag storage; location-site factor applied to each investment.

Appendix Table 2. Coastal Fertilizer Sites and Selected Site Characteristics, ASEAN Study, 1975

Location	Developed Grassroots	Port facilities Yes/No	Tons Ship capacity that could enter port	Location Site-Factor[a]
Atjeh (North Sumatra)	D	Yes	≤ 20,000	1.17
Palembang (South Sumatra)	D	Yes	≤ 7,000	1.17
Jatibarang (West Java)	G	No	≤ 10,000	1.21
Merak (West Java)	Will be D*	Yes*	≤ 40,000	1.21
Gresik (East Java)	G	No	≤ 12,000	1.23
Balikpapan (Borneo)	G	No	≤ 40,000	1.24
Santan (Borneo)	Floating		≤ 40,000	1.35
Brunei (East Malaysia)	D	Yes	≤ 30,000	1.20
Port Dixon (West Malaysia)	D	Yes	≤ 18,000	1.20
Kuantan (West Malaysia)	G	Uncertain	≤ 7,000	1.22
Iligan City (South Philippines)	D	Yes	≤ 30,000	1.18
Toledo City (Central Philippines)	D	Yes	≤ 20,000	1.17
Limay (North Philippines)	D	Yes	≤ 30,000	1.17
Poro Point (North Philippines)	G	Yes**	≤ 30,000	1.22
Bangkok (Thailand)	D	Yes	≤ 40,000	1.17

[a]Factor used to increase plant investment for infrastructure items at each location as based on ammonia-urea complex. For Palembang 1.17 equals $26.5 MM composed of site preparation, $8 MM; construction equipment, $5 MM; miscellaneous equipment, $7 MM; jetty and pier, $5 mm; and additional housing, $1.5 MM.

*As a result of the development of Krakatau Steel Complex.

**Partially developed because of the Copper Industry.

Appendix Table 3. Basic Input Coefficients Employed, ASEAN Study, 1975

Process	Ammonia Nat. gas	Ammonia Fuel oil	Urea	Ammonium Sulfate	Sulfuric Acid	Phosphoric Acid	MAP	DAP	APP	SSP	TSP
INPUTS, Units/mt product											
Nat.gas[a], 1000 SCF	34.7	-									
Fuel oil[b], mt	-	0.965									
Sulfur, mt					0.344						0.476
Rock[c], mt						1.84				0.67	
Ammonia, mt			0.6	0.27			0.15	0.23	0.138		
Carbon Dioxide, mt			0.77								
Sulfuric acid, mt				0.75		1.49				0.36	
Phosphoric acid, mt							0.99	0.87	1.06		0.614
Boiler feed makeup[d], MGAL	0.62	0.4			0.33						
Cooling water treated[e], MGAL	2.08	3.32	0.8		6.8						
Cooling water raw[f], MGAL				4.5		8.0					
Steam[g], MLbs			3.0	1.5	-2.2	0.97	0.2	0.3	0.3	0.3	0.2
Electricity[h], kWh	33	50	75	19	12	144	22	22	25	33	28
Catalyst and chm., $	1.00	0.67									
Labor[i] (oper + main) man-hr	1.26	1.45	0.75	0.77	0.58	0.99	0.81	0.81	0.69	1.05	0.88
Labor[j] (bagging), man-hr			0.96	0.96			0.96	0.96	0.96	0.96	0.96
Bags, $/mt (50 ea x $45)			9.00	9.00			9.00	9.00	9.00	9.00	9.00
Dryer heat[k], MBTU/mt				247			247	479		479	479

[a] 1000 BTU/SCF; cost from $0.60 to $1.60/1000 SCF.

[b] 145,000 BTU/GAL; cost at $85/mt.

[c] 32% P_2O_5, 47% CaO

[d] Cost at $1.00/MGAL

[e] Cost at $0.25/MGAL

[f] Cost at $0.05/MGAL

[g] Steam cost, gas at $0.60 = $0.69/MLBS, gas at $1.60 = $1.82/MLBS: oil at $0.25/GAL = $1.97/MLBS.

[h] Electricity cost, gas at $0.60 = $.003/KwH; gas at $1.60 = $.007/KwH; oil at $0.25/GAL = $.007/KwH.

[i] Labor varied with capacity at average annual salary of $3,000/yr.

[j] Fixed cost per ton of bagged product at average annual salary of $2,000/yr.

[k] Obtained from gas or oil at the site.

Appendix Table 4. Fertilizer Nutrient Consumption 1965-1974, in ASEAN countries[a]

	Thailand	Indonesia	Philippines	Malaysia	ASEAN Total
	1000 mt of nutrients				
Nitrogen (N)					
1965	16	79	53	32	180
1966	18	84	58	40	200
1967	35	110	66	44	255
1968	52	105	64	42	263
1969	51	198	63	43	355
1970	49	106	101	52	308
1971	43	202	119	66	430
1972	62	196	122	67	447
1973	62	347	115	81	605
1974[b]	70	350	146	113	679
Phosphate (P_2O_5)					
1965	10	14	23	5	52
1966	11	8	25	7	51
1967	24	28	28	7	87
1968	36	13	24	7	80
1969	38	66	45	17	166
1970	45	63	64	17	189
1971	24	29	44	23	120
1972	43	23	50	12	128
1973	56	67	39	26	188
1974[b]	45	85	45	37	212
Potash (K_2O)					
1965	5	3	13	15	36
1966	5	2	30	16	53
1967	8	4	13	29	54
1968	13	6	30	33	82
1969	10	7	40	30	87
1970	11	8	38	56	113
1971	15	6	38	76	135
1972	23	5	37	75	140
1973	42	30	39	100	211
1974[b]	40	40	45	112	237

Source: IBRD, TVA/IFDC, FAO

[a]Singapore is grouped with Malaysia.

[b]Preliminary data obtained directly by IFDC personnel.

Appendix Table 5. Alternative Fertilizer Nutrient Demand Projection, ASEAN Group, 198[illegible]

Nutrient		N			P_2O_5	[illegible]
Country	Area	Low	High	Recommended		
		1,000 mt/year				
Indonesia	North Sumatra	68	96	128	22	[illegible]
	South Sumatra	34	48	64	11	[illegible]
	West Java	187	264	352	73	[illegible]
	Central Java	212	300	400	73	[illegible]
	East Java	297	420	560	93	[illegible]
	Borneo	9	12	16	3	[illegible]
	Celebes	26	36	48	9	[illegible]
	Lesser Sunda Islands	17	24	32	6	1
INDONESIA TOTAL		850	1,200	1,600	290	80
Malaysia[a]	West Malaysia	180	225	(225)	63	216
	East Malaysia	20	25	(25)	7	24
MALAYSIA TOTAL		200	250	(250)	70	240
Philippines	North Philippines	152	212	(212)	68	36
	Central Philippines	76	106	(106)	34	18
	South Philippines	152	212	(212)	68	36
PHILIPPINES TOTAL		380	530	(530)	170	90
THAILAND TOTAL		130	260	(260)	160	80
ASEAN TOTAL		1,560	2,240	2,640	690	490

[a] Includes Singapore.

Appendix Table 6. Natural Gas Supplies for Nitrogen Fertilizer Production, ASEAN Region, 1975

Country	Total proved and probable reserves[a] billion M^3 January 1, 1975	Production[a] Million M^3 Per Year	Gas flared[b] Million M^3 Per Year	Ammonia Potential[c], If 25% of reserves are used - No. of 1000 mt NH_3/day Plants
Indonesia	425	4,551	10,177	19.6
Philippines	-	-	-	
Thailand	28	-	-	1.3
Malaysia & Brunei[d]	623	144	3,172	28.8

[a]From International Petroleum Encyclopedia 1975, p. 296

[b]"First Estimates of Global Flaring of Natural Gas," Rotty, R. M. Atmospheric Environment 8, pp. 681-86, 1974.

[c]About 1,090 M^3 gas/ton ammonia; reserves of 5.4×10^9 M^3 for 1000 mt/day for 15 years.

[d]Mainly Brunei.

Appendix Table 7. Raw Material Availabilities and Cost by Site Location, ASEAN Study, 1975

Location	Natural Gas or Other[a]			Sulfur Elemental @$60 C.I.F.	Phosphate Rock[b] @$50 C.I.F.	Potash[c] @$60 C.I.F.	Sulfuric[e] Acid Byproduct @$10/mt
	Available	Price $/1000 SCF	Limitation (Equivalent net NH_3 day)				
Atjeh	Yes	1.60	2000	I	I	I	NI
Palembang	Yes	.60	1000	I	I	I	NI
Jatibarang	Yes	1.60	500	I	I	I	NI
Merak	Yes	1.60	500	I	I	I	NI
Gresik	No	-	-	I	I	I	NI
Balikpapan	Yes	.60	No Limit	I	I	I	NI
Santan	Yes	.60	No Limit	I	I	I	NI
Brunei	Yes	1.60	No Limit	I	I	I	NI
Port Dixon	No	-	-	I	I	I	NI
Kuantan	Yes	1.60	No Limit	I	I	I	NI
Illigan City	No	-	-	I	I	I	NI
Toledo City	No	-	-	I	I	I	NI
Limay	No	-	-	I	I	I	540,000 t/yr. avail.
Poro Point	No	-	-	I	I	I	NI
Bangkok	No	-	-	I	I	I[d]	250,000 t/yr. avail.
				I	I	I	NI

I = Imported; NI = Not Imported

[a]Fuel oil could be imported to all locations at $85/mt, C.I.F.

[b]Rock at 32% P_2O_5 and 47% CaO.

[c]Imported as KCl.

[d]Thailand has deposits of carnallite which may be exploited in the future, it is assumed to be competitive with imported KCl.

[e]At sulfuric acid locations, it will not be imported but produced from imported elemental sulfur; two locations in Philippines have byproduct sulfuric acid available from copper smelters. A potential exists for expansion of copper smelters thus making more byproduct sulfuric acid available.

Appendix Table 8. Raw Materials for Phosphate Production, ASEAN Region, 1975

COUNTRY	PHOSPHATE ROCK			SULFUR						POTASH		
				Elemental			Pyrites					
	Total Prov. & Probable Reser. (million mt)	Av. Grade % P_2O_5	An. Prod. 1000mt	Reserves ml. mt	Grade % S	An. Prod. 1000mt	Reserves ml. mt	Grade % S	An. Prod. 1000 mt	Reserves ml. mt	Grade % K_2O	An. Prod. 1000 mt
Indonesia	1	15.5	30	10	20	1.0	-	-	-	Some	9.4	-
Malaysia + Brunei	0.1	10-30	-	-	-	-	-	-	-	-	-	-
Philippines	0.8	17-31	1	20	25	-	60	2.5-48.0	-	-	-	-
Thailand	Small	16-18	-	-	-	-	-	-	-	Some	up to 16.9	-

Appendix Table 9. Chemical Analysis of Final Product, Intermediate, and Import Alternatives, Import Restrictions and Prices, ASEAN Study, 1975

Product or Intermediate	Chemical Analysis, wt. %			Import Price[a] $/mt [illegible]
	N	P_2O_5	K_2O	
Ammonia	82	0	0	*
Urea	46	0	0	200
Ammonium sulfate	20	0	0	*
Monoammonium phosphate	11	54	0	*
Diammonium phosphate	18	46	0	250
Single superphosphate	0	20	0	*
Triple superphosphate	0	46	0	175
Ammonium polyphosphate	11	57	0	*
Urea-ammonium polyphosphate	28	28	0	*
Potassium chloride	0	0	60	60
Phosphoric acid (54%)	0	54	0	*
Sulfuric acid (100%)	0	0	0	*

[a]1985 prices in constant 1975 dollars.

*Imports from outside the region were not possible for these products.

Appendix Table 10. Scenario A: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia (gas)	1,678	131.0		
Sub-total			205.6	34.9	240.5
Balikpapan	Urea	9,699	258.9		
	Ammonia (gas)	6,483	499.2		
Sub-total			758.1	181.9	940.0
TOTAL INDONESIA			963.7	216.8	1180.5
Poro Point	Ammonium phosphate	1,032	16.7		
	Phosphoric acid	1,278	37.1		
Sub-total			53.8	11.8	65.6
Toledo City	Ammonium phosphate	2,065	31.6		
	Phosphoric acid	2,555	74.1		
Sub-total			105.7	18.0	123.7
TOTAL PHILIPPINES			159.5	29.8	189.3

Appendix Table 11. Scenario B: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia	1,678	131.0		
Sub-total			205.6	34.9	240.5
Balikpapan	Urea	4,798	128.1		
	Ammonia (gas)	2,984	233.3		
Sub-total			361.4	86.7	448.1
TOTAL INDONESIA			567.0	121.6	688.6
Kuantan	Urea	1,800	48.1		
	Ammonia (gas)	1,080	85.3		
TOTAL MALAYSIA			133.4	29.3	162.7
Poro Point	Ammonium phosphate	1,032	16.7		
	Phosphoric acid	1,278	37.1		
Sub-total			53.8	11.8	65.6
Toledo City	Urea	1,800	48.1		
	Ammonium phosphate	2,065	31.6		
	Phosphoric acid	2,555	74.1		
	Ammonia (fuel oil)	1,629	166.1		
Sub-total			319.9	54.4	374.3
TOTAL PHILIPPINES			373.7	66.2	439.9
Bangkok	Urea	1,161	36.9		
	Ammonia (fuel oil)	697	90.8		
TOTAL THAILAND			127.7	21.7	149.4

Appendix Table 12. Scenario C: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia (gas)	1,675	131.0		
Sub-total			205.6	34.9	240.5
Gresik	Ammonium phosphate	808	13.2		
	Sulfuric acid	1,217	21.9		
	Phosphoric acid	1,000	29.0		
Sub-total			64.1	14.7	78.8
Balikpapan	Urea	4,809	128.4		
	Ammonia (gas)	2,885	225.7		
Sub-total			354.1	85.0	439.1
TOTAL INDONESIA			623.8	134.6	758.4
Kuantan	Urea	1,709	46.5		
	Ammonia (gas)	1,080	78.0		
TOTAL MALAYSIA			124.5	27.4	151.9
Poro Point	Ammonium phosphate	411	8.9		
	Phosphoric acid	508	19.7		
Sub-total			28.6	6.3	34.9
Toledo City	Ammonium phosphate	1,070	16.4		
	Phosphoric acid	1,325	38.4		
	Sulfuric acid	338	12.2		
	Urea	2,070	55.3		
	Ammonia (fuel oil)	1,629	166.2		
Sub-total			288.5	49.0	337.5
TOTAL PHILIPPINES			317.1	55.3	372.4
Bangkok	Ammonium phosphate	808	13.2		
	Phosphoric acid	1,000	29.0		
	Sulfuric acid	1,490	28.6		
	Urea	1,018	34.4		
	Ammonia (fuel oil)	780	95.2		
TOTAL THAILAND			200.4	34.1	234.5

Appendix Table 13. Scenario D: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total Cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia (gas)	1,678	131.0		
Sub-total			205.6	34.9	240.5
Gresik	Ammonium phosphate	907	14.2		
	Sulfuric acid	1,400	23.9		
	Phosphoric acid	1,123	32.6		
Sub-total			70.7	16.2	86.9
Balikpapan	Urea	9,699	258.9		
	Ammonia (gas)	6,383	499.2		
Sub-total			758.1	181.9	940.0
TOTAL INDONESIA			1,034.4	233.0	1,267.4
Poro Point	Ammonium phosphate	411	8.9		
	Phosphoric acid	509	19.7		
Sub-total			28.6	5.7	34.3
Toledo City	Ammonium phosphate	888	14.1		
	Phosphoric acid	1,098	31.8		
Sub-total			45.9	7.8	53.7
TOTAL PHILIPPINES			74.5	13.5	88.0
Bangkok	Ammonium phosphate	892	14.1		
	Sulfuric acid	1,645	28.1		
	Phosphoric acid	1,104	32.0		
TOTAL THAILAND			74.2	12.6	86.8

Appendix Table 14. Scenario E: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia (gas)	1,678	131.6		
Sub-total			206.2	34.9	241.1
Jatibarang	Urea	1,833	48.9		
	Ammonia (gas)	1,100	86.0		
Sub-total			134.9	28.3	163.2
Gresik	Ammonium phosphate	907	14.2		
	Sulfuric acid	1,400	23.9		
	Phosphoric acid	1,123	32.6		
Sub-total			70.7	16.2	86.9
Balikpapan	Urea	2,977	79.5		
	Ammonia (gas)	1,786	139.7		
Sub-total			219.2	52.6	271.8
TOTAL INDONESIA			631.0	132.0	763.0
Kuantan	Urea	1,800	48.1		
	Ammonia (gas)	1,080	85.3		
TOTAL MALAYSIA			133.4	29.3	162.7
Poro Point	Ammonium phosphate	411	8.9		
	Phosphoric acid	509	19.7		
Sub-total			28.6	5.7	34.3
Toledo City	Urea	2,100	56.1		
	Ammonium phosphate	888	14.1		
	Phosphoric acid	1,098	31.8		
	Ammonia (fuel oil)	1,629	166.2		
Sub-total			268.2	45.6	313.8
TOTAL PHILIPPINES			296.8	51.3	348.1
Bangkok	Urea	989	26.5		
	Ammonium phosphate	892	14.1		
	Sulfuric acid	1,645	28.1		
	Phosphoric acid	1,104	32.0		
	Ammonia (fuel oil)	781	95.3		
TOTAL THAILAND			196.0	33.3	229.3

Appendix Table 15. Scenario F: Capacity Expansion Characteristics, ASEAN Countries, 1985

Location	Plant Type	Size (t/d)	Investment (mil. US$)	Site cost (mil. US$)	Total cost (mil. US$)
Palembang	Urea	2,794	74.6		
	Ammonia (gas)	1,678	131.0		
Sub-total			205.6	34.9	240.5
Gresik	Ammonium phosphate	1,302	101.8		
	Sulfuric acid	2,128	36.4		
	Phosphoric acid	1,611	46.7		
Sub-total			184.9	42.5	227.4
Balikpapan	Urea	2,627	70.1		
	Ammonia (gas)	1,756	137.3		
Sub-total			207.4	49.8	257.2
TOTAL INDONESIA			597.9	127.2	725.1
Kuantan	Urea	1,739	47.0		
	Ammonia (gas)	1,110	86.8		
	Ammonium phosphate	314	7.9		
	Sulfuric acid	579	14.9		
	Phosphoric acid	389	17.4		
TOTAL MALAYSIA			174.0	38.3	212.3
Limay	Urea	1,833	48.9		
	Ammonia (fuel oil)	1,100	86.0		
Sub-total			134.9	29.7	164.6
Toledo City	Urea	1,800	48.1		
	Ammonia (fuel oil)	1,252	97.9		
	Ammonia phosphate	796	13.1		
	Phosphoric acid	947	28.0		
Sub-total			187.1	31.8	218.9
TOTAL PHILIPPINES			322.0	61.5	383.5
Bangkok	Urea	1,678	45.9		
	Ammonia (fuel oil)	1,158	90.5		
	Ammonium phosphate	718	12.3		
	Sulfuric acid	1,324	23.1		
	Phosphoric acid	889	26.9		
TOTAL THAILAND			198.7	33.8	232.5

Appendix Table 16. Scenario A: Total Production (Existing Plus Added Capacity) of Final and Intermediate Products, ASEAN Countries, 1985 (thousand metric tons)

Source	Final Products		Intermediates			
	Urea	MAP	Phosphoric Acid	Ammonia	FO Ammonia[1]	Sulfuric Acid
Atjeh						
Palembang	1,650.0			990.0		
Jatibarang						
Merak						
Gresik	56.3				33.7	
Balikpapan	2,857.8			1,910.2		
Santan						
Kuantan						
Port Dickson						
Brunei						
Limay						
Poro Point		425.9	421.7			
Toledo City		851.9	843.3			
Iligan City						
Bangkok						
TOTAL	4,564.1	1,277.8	1,265.0	2,900.2	33.7	

[1] Fuel oil-based ammonia.

Appendix Table 17. Scenario B: Total Production (Existing Plus Added Capacity) of Final and Intermediate Products, ASEAN Countries, 1985 (thousand metric tons)

	Final Products		Intermediates			
Source	Urea	MAP	Phosphoric Acid	Ammonia	FO Ammonia	Sulfuric Acid
Atjeh						
Palembang	1,650.0			990.0		
Jatibarang						
Merak						
Gresik	56.3				33.7	
Balikpapan	1,413.7			879.4		
Santan						
Kuantan	530.4			318.2		
Port Dickson						
Brunei						
Limay						
Poro Point		425.9	421.7			
Toledo City	530.4	851.9	843.3		480.0	
Iligan City						
Bangkok	383.3				230.0	
TOTAL	4,564.1	1,277.8	1,265.0	2,187.6	743.7	

Appendix Table 18. Scenario C: Total Production (Existing Plus Added Capacity) of Final and Intermediate Products, ASEAN Countries, 1985 (thousand metric tons)

Source	Final Products		Intermediates			
	Urea	MAP	Phosphoric Acid	Ammonia	FO Ammonia	Sulfuric Acid
Atjeh						
Palembang	1,650.0			990.0		
Jatibarang						
Merak						
Gresik	56.3	333.3	330.0		62.5	491.7
Balikpapan	1,417.2			850.3		
Santan						
Kuantan	530.4			318.2		
Port Dickson						
Brunei						
Limay						
Poro Point		169.5	167.8			
Toledo City	610.2	441.6	437.2		480.0	111.4
Iligan City						
Bangkok	300.0	333.3	330.0		230.0	491.7
TOTAL	4,564.1	1,277.7	1,265.0	2,158.5	772.5	1,094.8

Appendix Table 19. Scenario D: Total Production (Existing Plus Added Capacity) of Final and Intermediate Products, ASEAN Countries, 1985 (thousand metric tons)

	Final Products		Intermediates			
Source	Urea	MAP	Phosphoric Acid	Ammonia	FO Ammonia	Sulfuric Acid
Atjeh						
Palembang	1,650.0			990.0		
Jatibarang						
Merak						
Gresik	56.3	374.2	370.5		62.5	552.0
Balikpapan	2,857.8			1,880.9		
Santan						
Kuantan						
Port Dickson						
Brunei						
Limay						
Poro Point		169.5	167.8			
Toledo City		366.1	362.4			
Iligan City						
Bangkok		368.0	364.3			542.8
TOTAL	4,564.1	1,277.8	1,265.0	2,870.9	62.5	1,094.8

Appendix Table 20. Scenario E: Total Production (Existing Plus Added Capacity) of Final and Intermediate Products, ASEAN Countries, 1985 (thousand metric tons)

	Final Products		Intermediates			
Source	Urea	MAP	Phosphoric Acid	Ammonia	FO Ammonia	Sulfuric Acid
Atjeh						
Palembang	1,650.0			990.0		
Jatibarang	540.2			324.1		
Merak						
Gresik	56.3	374.2	370.5		62.5	552.0
Balikpapan	877.2			526.3		
Santan						
Kuantan	530.4			318.2		
Port Dickson						
Brunei						
Limay						
Poro Point		169.5	167.8			
Toledo City	618.7	366.1	362.4		480.0	
Iligan City						
Bangkok	291.3	368.0	364.3		230.0	542.8
TOTAL	4,564.1	1,277.8	1,265.0	2,158.6	772.5	1,094.8

Appendix Table 21. Estimated Supply Requirements of Domestic Materials by Specified Plant Locations for Scenarios A, C, and E, ASEAN Countries, 1985

Source	Scenario A		Scenario C		Scenario E	
	Natural gas mscf	Sulfuric acid--1,000 metric tons	Natural gas mscf	Sulfuric acid--1,000 metric tons	Natural gas mscf	Sulfuric acid--1,000 metric tons
Atjeh						
Palembang	34,353.0		34,353.0		34,353.0	
Jatibarang					11,246.5	
Merak						
Gresik						
Balikpapan	66,285.1		29,505.8		18,263.6	
Santan						
Kuantan			11,042.0		11,042.0	
Port Dickson						
Brunei						
Limay						
Poro Point		628.3		250.0		250.0
Toledo City		1,256.6		540.0		540.0
Iligan City						
Bangkok						
TOTAL	100,638.1	1,884.9	74,900.8	790.0	74,905.1	790.0

Appendix
Table 22. Estimated Imports to Specified Plant Locations of Intermediates and Raw Materials in 1,000 Metric Tons for Scenarios A, C, and E, ASEAN Countries, 1985

	Scenario											
	A				C				E			
Plant Locations	Elemental Sulfur	Phosphate Rock	Fuel Oil	Total	Elemental Sulfur	Phosphate Rock	Fuel Oil	Total	Elemental Sulfur	Phosphate Rock	Fuel Oil	Total
Atjeh												
Palembang												
Jatibarang												
Merak												
Gresik			32.6	32.6	169.1	607.2	60.3	836.6	189.9	681.7	60.3	931.9
Balikpapan												
Santan												
Kuantan												
Port Dickson												
Brunei												
Limay												
Poro Point		775.9		775.9		308.7		308.7		308.7		308.7
Toledo City		1551.7		1551.7	38.3	804.5	463.2	1306.0		666.8	463.2	1130.0
Iligan City												
Bangkok					169.1	607.2	221.9	998.2	186.7	670.4	221.9	1079.0
TOTALS		2327.6	32.6	2360.2	376.5	2327.6	745.4	3449.5	376.6	2327.6	745.4	3449.6

Appendix Table 23. Estimated Finished Product Shipments from Active Plant Locations to Specified Demand Regions, Scenario A, ASEAN Countries

Demand Region	Active Origins: Urea (1,000 metric tons)				MAP (1,000 metric tons)		
	Palembang	Gresik	Balikpapan	Total	Poro Point	Toledo City	Total
North Sumatra	198.4			198.4	43.0		43.0
South Sumatra	99.2			99.2	21.5		21.5
West Java	396.8		145.0	541.8		134.3	134.3
Central Java			620.1	620.1		134.3	134.3
East Java		56.3	815.7	872.0		171.9	171.9
Borneo			24.8	24.8		5.4	5.4
Sulawasi			74.4	74.4		16.1	16.1
Lesser Sunda Islands			49.6	49.6		10.7	10.7
West Malaysia	461.2			461.2		116.7	116.7
East Malaysia			51.2	51.2		13.0	13.0
Northern Philippines			430.8	430.8	125.9		125.9
Central Philippines			215.4	215.4		63.0	63.0
South Philippines			430.8	430.8		125.9	125.9
Thailand	494.4			494.4	235.6	60.7	296.3
TOTAL	1,650.0	56.3	2,857.8	4,564.1	426.0	852.0	1,278.0

Appendix
Table 24. Estimated Finished Product Shipments From Active Plant Locations to Specified Demand Regions, Scenario C, ASEAN Countries, 1985

	Active Origins											
	Urea (1,000 metric tons)							MAP (1,000 metric tons)				
Demand Region	Palembang	Gresik	Balikpapan	Kuantan	Toledo City	Bangkok	Total	Gresik	Poro Point	Toledo City	Bangkok	Total
North Sumatra	198.4						198.4		43.0			43.0
South Sumatra	99.2						99.2		0.6	20.9		21.5
West Java	541.8						541.8	27.2		107.0		134.2
Central Java	620.1						620.1	134.3				134.3
East Java	14.0	56.3	801.7				872.0	171.9				171.9
Borneo			24.8				24.8			5.4		5.4
Sulawasi			74.4				74.4			16.1		16.1
Lesser Sunda Islands			49.6				49.6			10.7		10.7
West Malaysia				461.2			461.2			79.6	37.0	116.6
East Malaysia	51.2						51.2			13.0		13.0
Northern Philippines			35.9		394.8		430.7		125.9			125.9
Central Philippines					215.4		215.4			63.0		63.0
South Philippines			430.8				430.8			125.9		125.9
Thailand	125.2			69.1		300.0	494.3				296.3	296.3
TOTAL	1,649.9	56.3	1,417.2	530.3	610.2	300.0	4,563.9	333.3	169.5	441.6	333.3	1,277.8

Appendix
Table 25. Estimated Finished Product Shipments From Active Plant Locations to Specified Demand Regions, Scenario E, ASEAN Countries, 1985

	Active Origins												
	Urea (1,000 metric tons)								MAP (1,000 metric tons)				
Demand Region	Palembang	Jatibarang	Gresik	Balikpapan	Kuantan	Toledo City	Bangkok	Total	Gresik	Poro Point	Toledo City	Bangkok	Total
North Sumatra	198.4							198.4		43.0			43.0
South Sumatra	99.2							99.2		0.6	20.9		21.5
West Java	541.8							541.8	68.1		66.2		134.3
Central Java	79.9	540.2						620.1	134.3				134.3
East Java	545.5		56.3	270.2				872.0	171.9				171.9
Borneo				24.8				24.8			5.4		5.4
Sulawasi				74.4				74.4			16.1		16.1
Lesser Sunda Islands				49.6				49.6			10.7		10.7
West Malaysia					461.2			461.2			45.0	71.7	116.7
East Malaysia	51.2							51.2			13.0		13.0
Northern Philippines				27.5		403.3		430.8		125.9			125.9
Central Philippines						215.4		215.4			63.0		63.0
South Philippines				430.8				430.8			125.9		125.9
Thailand	133.9				69.1		291.3	494.3				296.3	296.3
TOTAL	1,649.9	540.2	56.3	877.3	530.3	618.7	291.3	4,564.0	374.3	169.5	366.2	368.0	1,278.0

Appendix Table 26. Estimated Interplant Shipments of Ammonia in 1,000 Metric Tons of Material by Origin and Destination for Scenarios A, C, and E, ASEAN Countries, 1985

Destination (Plant Location)	Scenario A	Scenario C	Scenario E
	Active Origin		
	Balikpapan	Toledo City	Toledo City
Atjeh			
Palembang			
Jatibarang			
Merak			
Gresik		21.7	27.9
Balikpapan			
Santan			
Kuantan			
Port Dickson			
Brunei			
Limay			
Poro Point	65.2	25.9	25.9
Toledo City	130.4		
Iligan City			
Bangkok			
TOTAL	195.6	47.6	53.8

Appendix Table 27. Selected Shipping Distances and Freight Rates, ASEAN Study, 1975

Basis: Bulk Cost, $/ton = $4.60 + (.00125 X N miles)[a]

From	To	Distance[b], N miles	Freight, $/ton
Basra, Iraq (Pers. Gulf)	Manila	5,246	11.16
Kenai, Alaska	Manila	5,244	11.16
Yokohama, Japan	Manila	1,758	6.80
Balikpapan	Manila	1,435	6.39
Palembang	Manila	1,764	6.81
Toledo City	Manila	441	5.15
Tampa, Florida	Manila	10,608	17.86
Melilla, Morocco	Manila	7,964	14.60
Aqaba, Jordan	Manila	6,167	12.30

[a]Formula used internally in the model for freight cost for bulk granular product such as urea or monoammonium phosphate.

[b]Source, Marine Distance and Speed Table, Edward W. Sweetman Company, New York, Third Printing, March, 1970.

Appendix Table 28. Plant Investment Requirements and Estimated Production Cost of Bulk Urea From an Ammonia Urea Complex in Selected Locations, ASFAM Study, 1975

Basis: 1000 mt/day ammonia and 1667 mt/day urea, operating at 89% capacity utilization

Location:	Palembang	Balikpapan	Toledo City	Persian Gulf		
Gas cost, $/1000 SCF	0.60	0.60	-	0.10	0.25	0.50
Fuel oil, $/mt	-	-	85	-	-	-
Location-site factor	1.17	1.24	1.17		1.24	
Ammonia plant investment, $MM	96.595	102.374	125.073		102.374	
Urea plant investment, $MM	58.266	61.752	58.266		61.752	
Total (no working capital), $MM	154.861	164.126	183.339		164.126	
Ammonia production cost, $/mt	85.7	89.1	165.6	71.4	76.7	85.6
Urea production cost, $/mt	80.5	83.8	133.5	71.0	74.9	81.2

Appendix Table 29. Estimated Investment Requirement, Production Cost[a] and Ex-factory Prices of Granular Monoammonium Phosphate, Selected Locations, ASEAN Study, 1975

Basis: 1,651 mt/day sulfuric acid, 1,111 mt/day 54% acid, and 1,132 mt/day MAP, at 100% capacity.

LOCATION:	TOLEDO CITY	FLORIDA		MOROCCO	
Sulfur, $/mt	Byproduct sulfuric acid at $10	$30	$70	$30	$70
Rock, $/mt	50	$30	$70	$30	$70
Location-Site Factor	1.17	1.00		1.17	
Sulfuric Acid Plant Investment, $MM	0	26.750		31.300	
Phosphoric Acid Plant Investment, $MM	36.840	31.490		36.840	
Granular MAP Plant Investment, $MM	20.590	17.600		20.590	
Total (No working capital), $MM	57.430	75.840		88.730	
Sulfuric Acid Production Cost, $/mt	10 (byproduct)	23.1	37.1	26.1	40.1
Phosphoric Acid Production Cost, $/mt	135.4	113.0	209.1	122.1	143.3
Granular MAP Production Cost, $/mt	180.8	156.5	253.5	169.4	266.2
($/mt plant nutrient)[b]	(278.2)	(240.8)	(390.0)	(260.6)	(409.5)
Ex-Factory Price, 20% ROI, $/mt	233.9	220.9	332.6	242.9	354.5
For Bulk Granular MAP ($/mt plant nutrient)	(359.9)	(339.9)	(511.7)	(373.7)	(545.4)

[a]In 1975 dollars.

[b]In the model diammonium phosphate (18-46-0) could be brought to the region C.I.F. for $250/mt or $390.6/mt of plant nutrient.

Appendix Table 30. Estimated Plant Investment Requirements, Production Cost and Landed Value (Ex-factory plus delivery charges) for Granular Diammonium Phosphate for Selected Locations, ASEAN Study, 1975[a]

BASIS: 849 MT/DAY DAP AT 100% CAPACITY

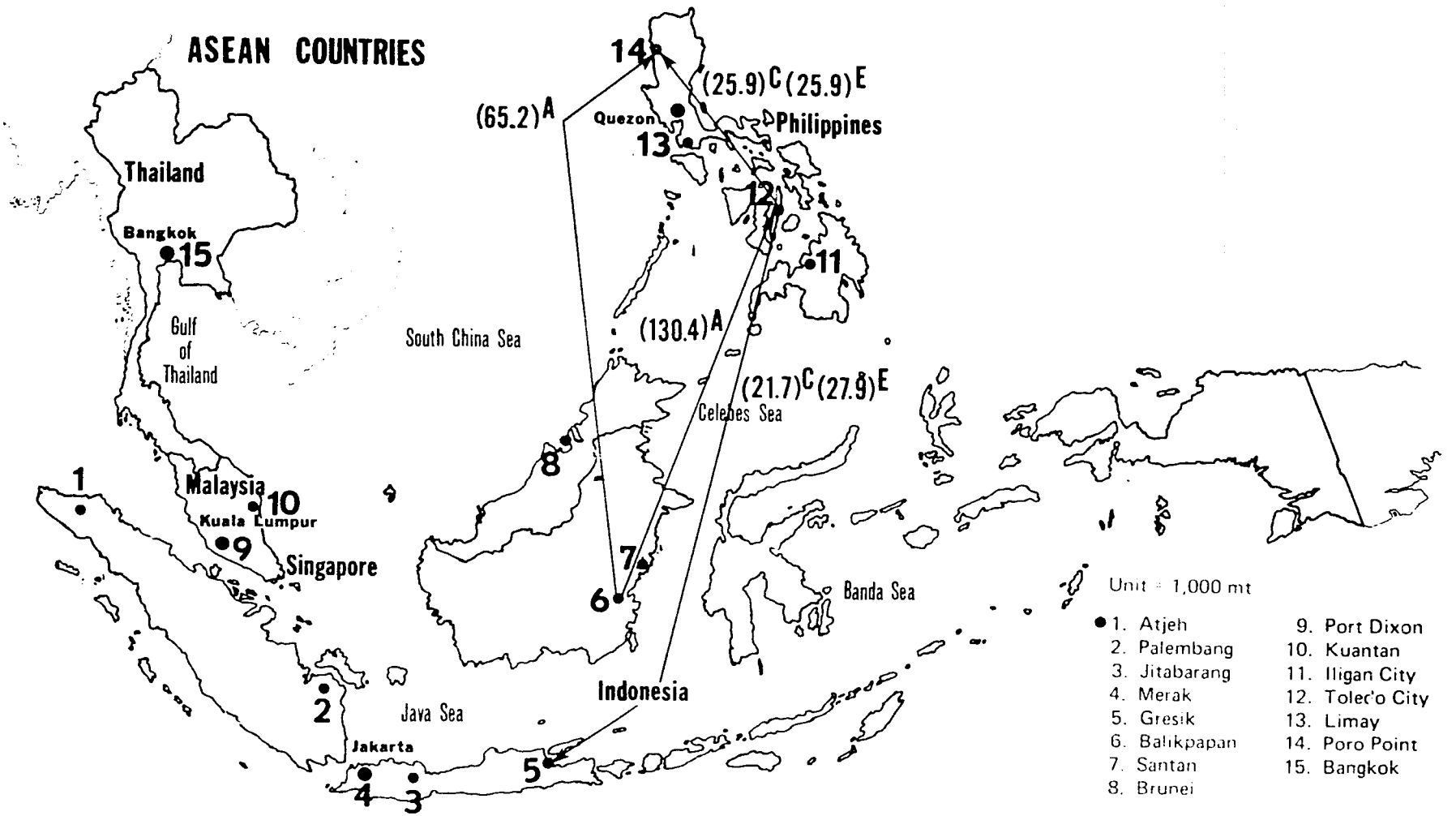
LOCATION:	TOLEDO CITY	FLORIDA		MOROCCO	
Sulfur, $/mt	Byproduct sulfuric acid at $10	$ 30	$ 70	$ 30	$ 70
Rock, $/mt	$50	30	70	30	70
Location - Site Factor	1.17	1.00		1.17	
Granular DAP Plant Investment, $MM	20.590	17.600		20.590	
Production Cost, $/mt	183.9	161.9	247.0	173.5	258.6
($/mt Plant Nutrient)	(287.3)	(253.0)	(385.9)	(271.1)	(404.1)
Ex-Factory Price, 20% ROI, $/mt	237.3	224.6	322.7	245.1	343.2
(For Bulk Granular DAP, $/mt Plant Nutrient)	(370.8)	(350.9)	(504.2)	(383.0)	(536.3)
Delivered Price of Granular Bagged DAP to Manila, $/mt	295.5[b]	295.5[c]	393.6[c]	312.7[d]	410.8[d]
($/mt Plant Nutrient)	(461.7)	(461.7)	(615.0)	(488.6)	(641.9)

[a]In 1975 dollars.

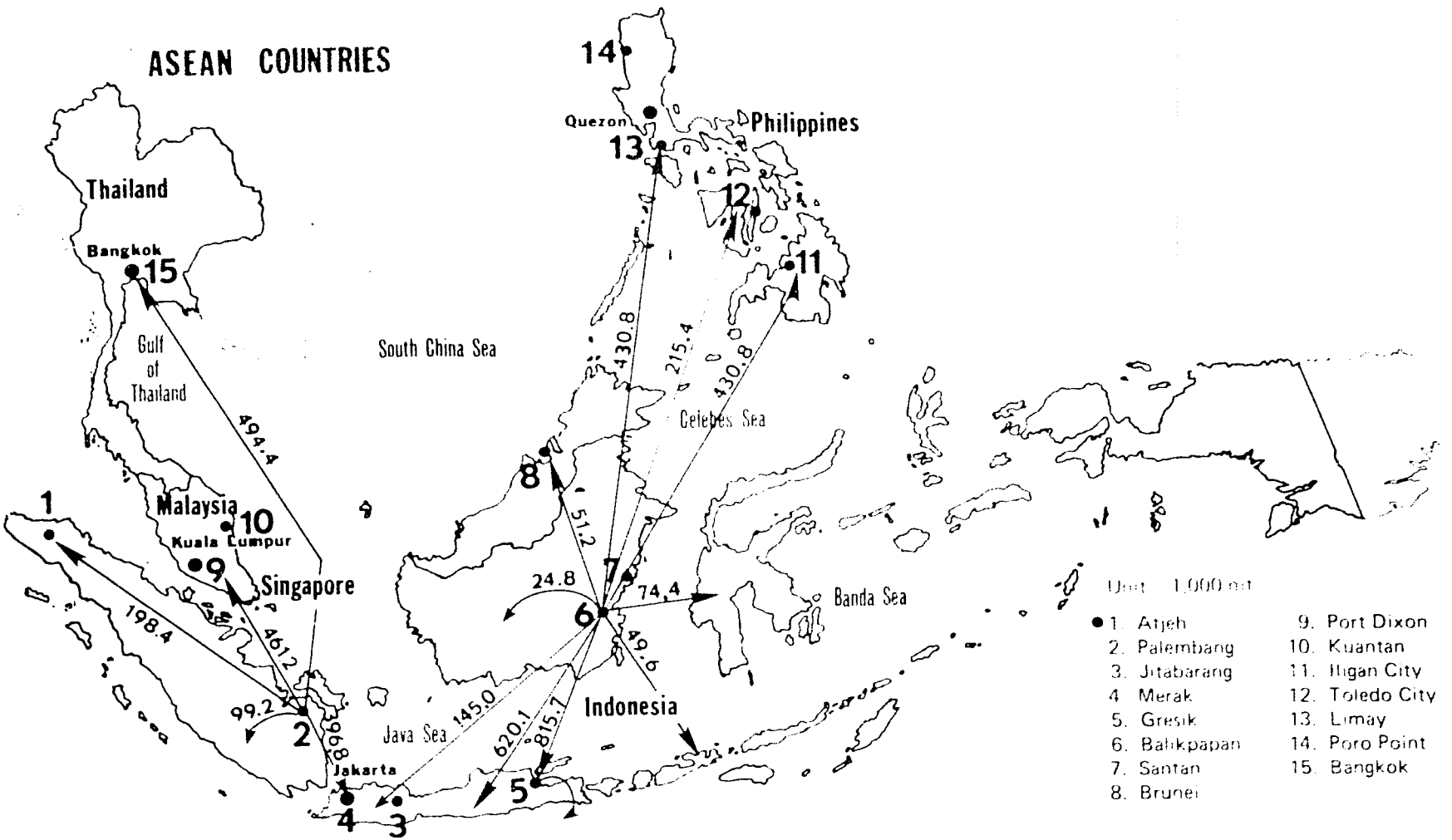
[b]Contains $58.15 delivery charges and other added to ex-factory price.

[c]Contains $70.86 delivery charges and other added to ex-factory price.

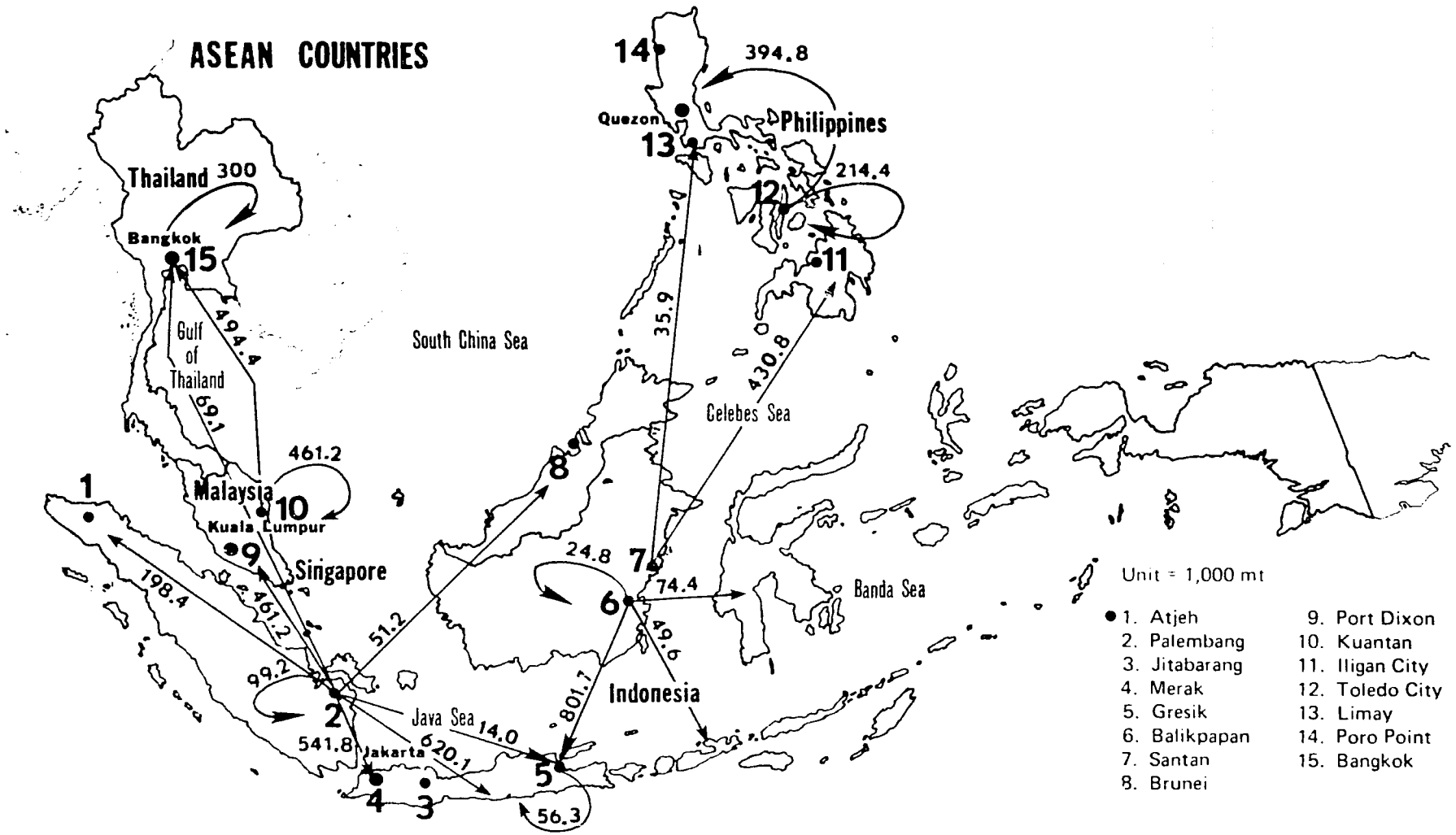
[d]Contains $67.60 delivery charges and other added to ex-factory price.



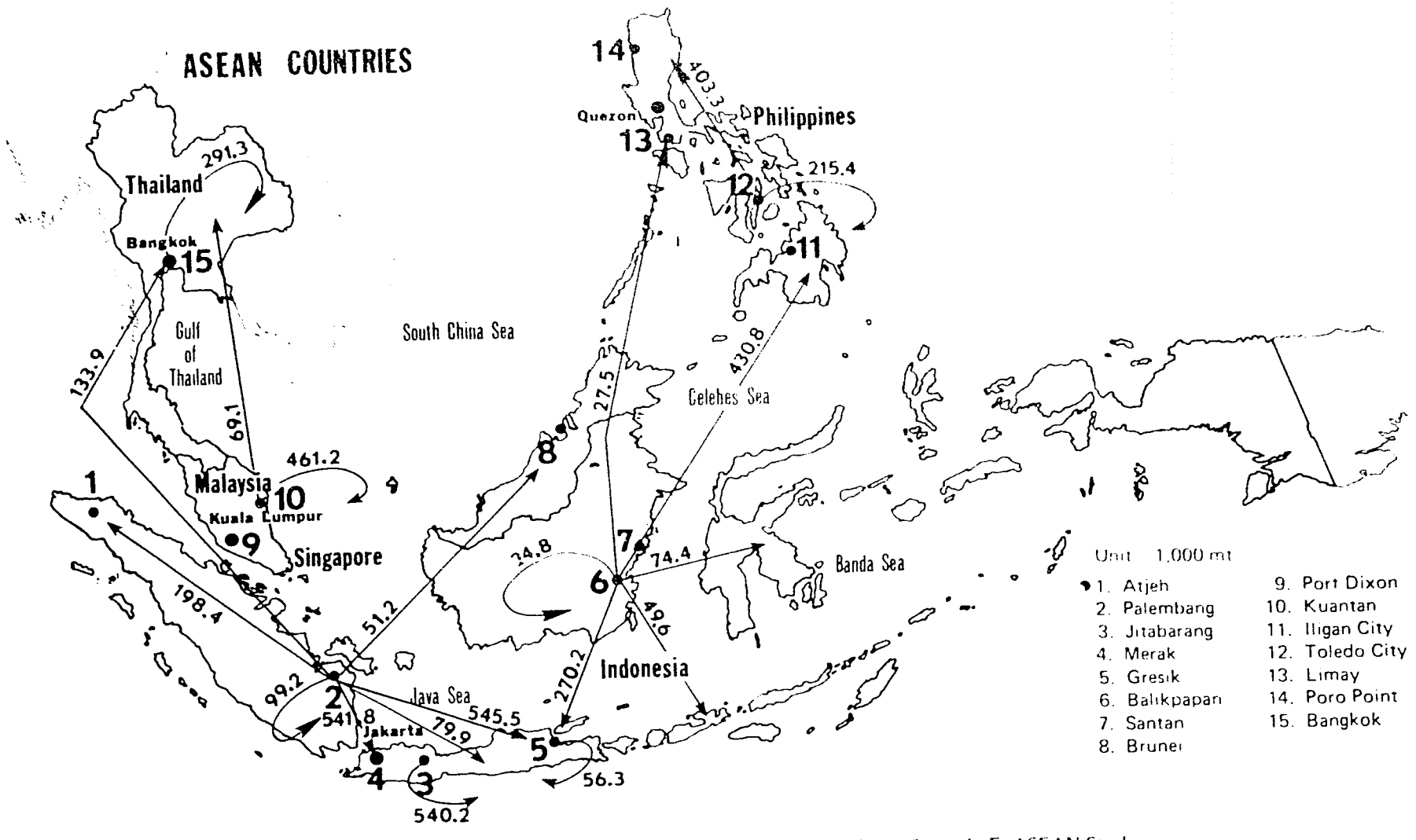
Appendix Figure 1. 1985 Least-Cost Shipping Patterns for Ammonia, Scenarios A, C, and E, ASEAN Study



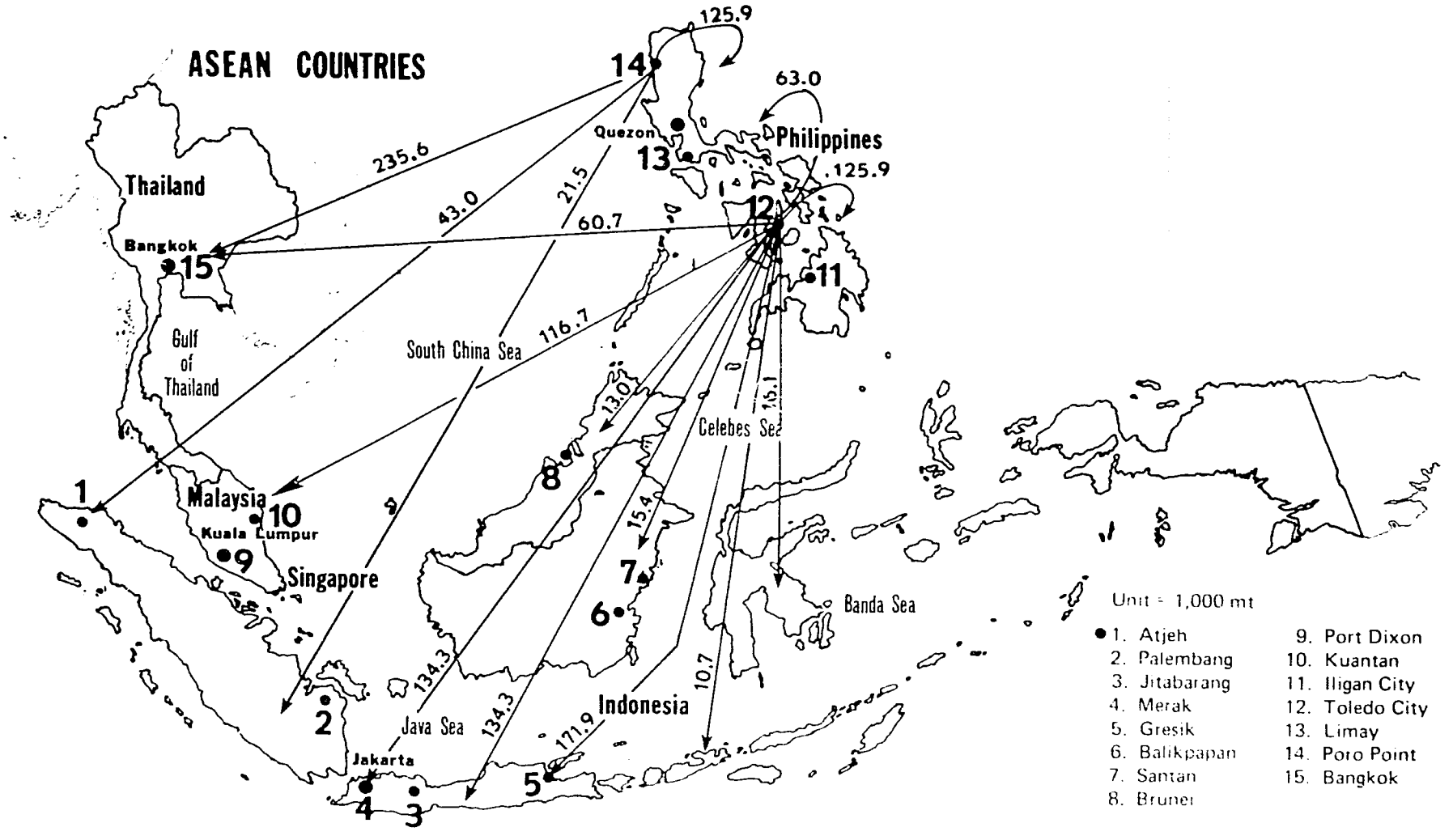
Appendix Figure 2. 1985 Least Cost Shipping Patterns for Urea, Scenario A, ASEAN Study



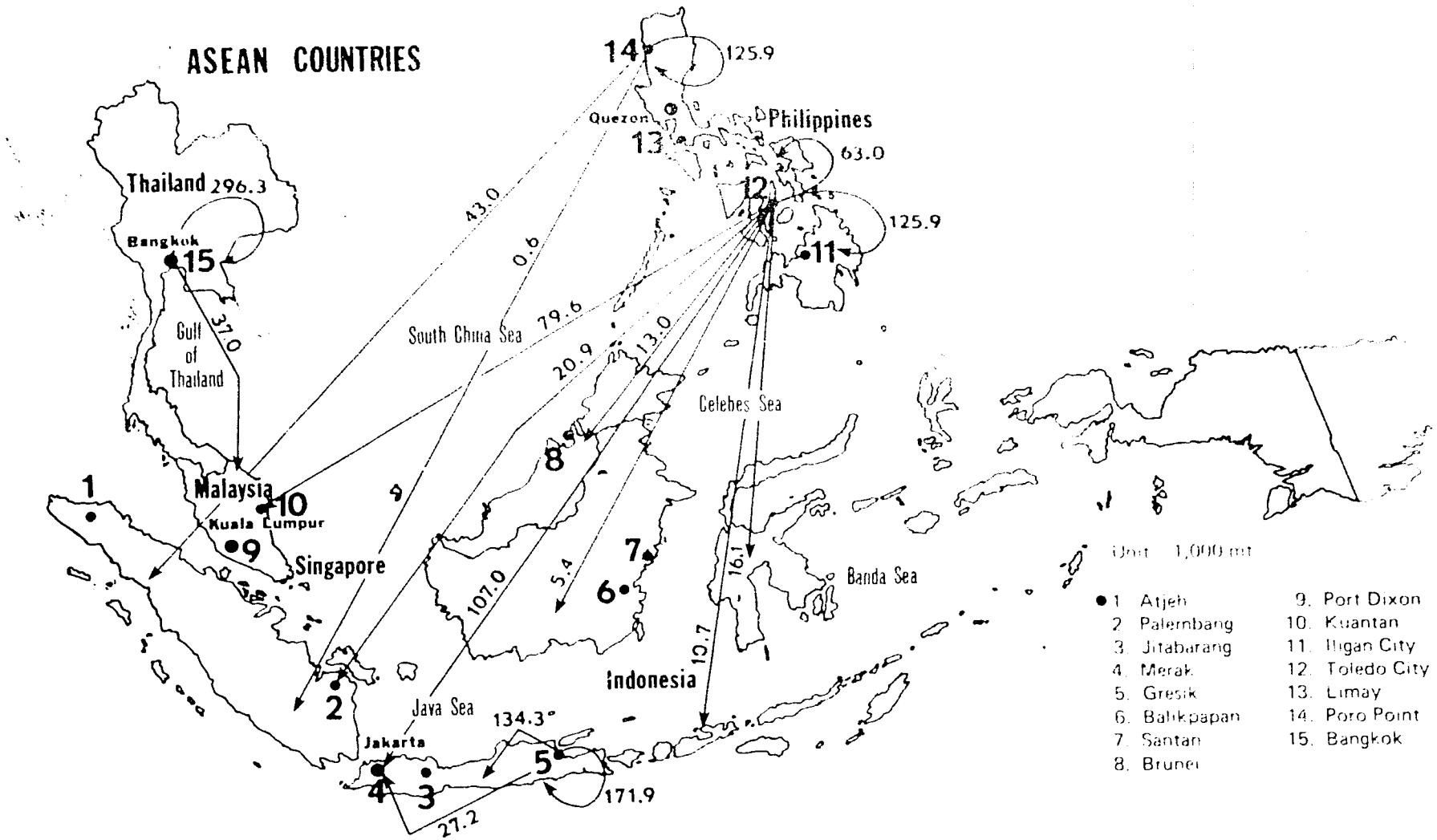
Appendix Figure 3. 1985 Least-Cost Shipping Patterns for Urea, Scenario C, ASEAN Study



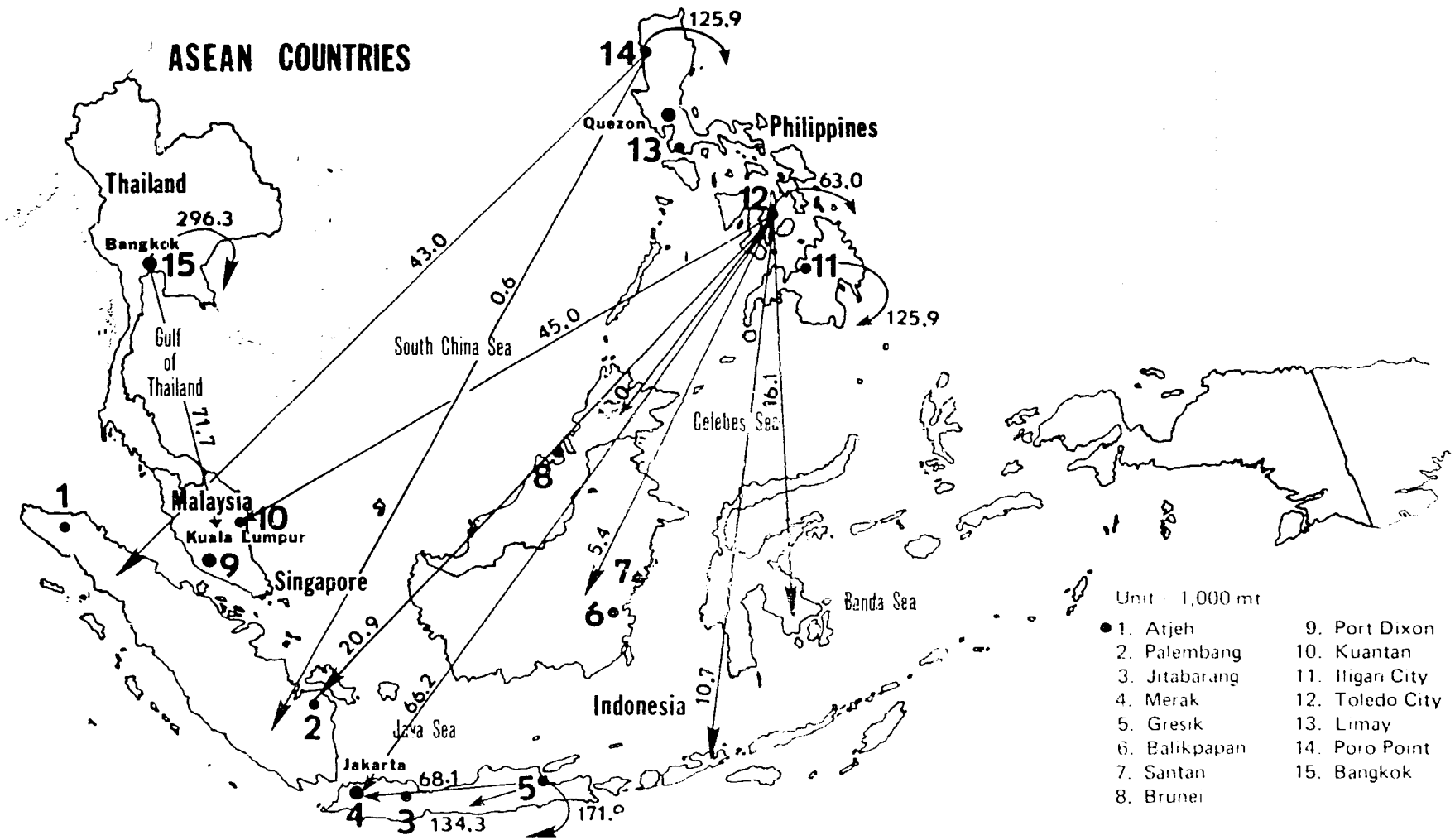
Appendix Figure 4. 1985 Least-Cost Shipping Patterns for Urea, Scenario E, ASEAN Study



Appendix Figure 5. 1985 Least-Cost Shipping Patterns for MAP, Scenario A, ASEAN Study



Appendix Figure 6. 1985 Least-Cost Shipping Patterns for MAP, Scenario C, ASEAN Study



Appendix Figure 7. 1985 Least-Cost Shipping Patterns for MAP, Scenario E, ASEAN Study

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